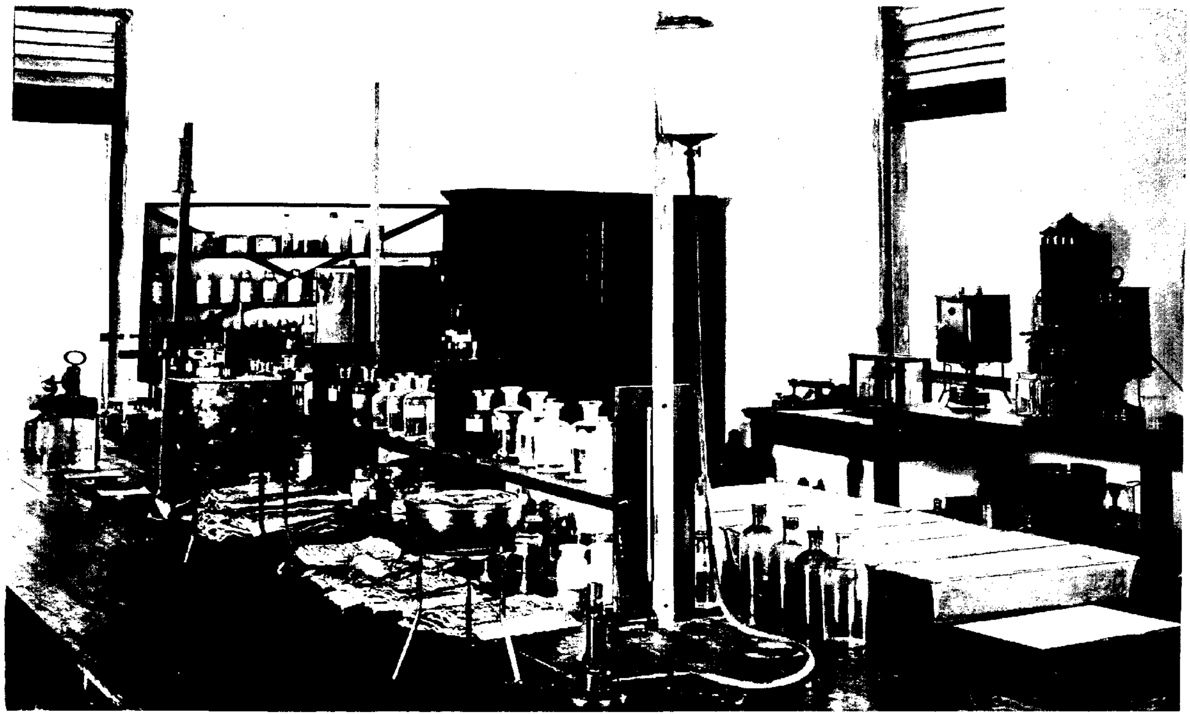
THE PREPARATION OF
PLANTATION RUBBER



VIEW OF INTERIOR OF RESEARCH LABORATORY, PETALING

[*Frontispiece.*

THE PREPARATION OF

PLANTATION RUBBER

A REFERENCE TEXT-BOOK FOR PRACTICAL PLANTERS

SUMMARISING THE INFORMATION CONTAINED IN THE LOCAL REPORTS OF THE RESIDENT CHEMIST DURING THE PERIOD 1910-1913

BY

SIDNEY MORGAN, A.R.C.Sc., F.C.S.

SENIOR SCIENTIFIC OFFICER AND RESIDENT CHEMIST IN THE FEDERATED MALAY STATES FOR THE RUBBER GROWERS' ASSOCIATION

PUBLISHED BY

THE RUBBER GROWERS' ASSOCIATION

1 OXFORD COURT, CANNON STREET

LONDON

PRINTED BY
WILLIAM CLOWES AND SONS, LIMITED,
LONDON AND BECCLES.

INTRODUCTORY REMARKS

It has been the feeling for some time amongst managers of estates which guarantee the Research Fund that some more permanent form of publication should be found than the small local reports. These have been issued at more or less regular intervals during the past three years; and, we are assured, have proved of considerable interest and benefit to most readers. Unfortunately in many cases sufficient care of them was not taken, with the result that often the report required for immediate reference could not be found. Again, it was often found to be a matter of some labour to have to read through all the back numbers in search of some point of interest. Furthermore, requests were continually being received from estates and other sources for previous numbers of reports. These requests the Local Committee felt unable to comply with, as cases have been known in which reports obtained in this manner were intended for persons not entitled to receive them. On the whole, therefore, the Local Committee considered it advisable that all the subject matter and discussions contained in the local reports should be incorporated in book form and adequately indexed. It was pointed out that, published in this form, the information would have an enhanced value inasmuch as reference to any particular point would be such a comparatively easy matter.

This volume therefore contains all the points of interest which have appeared in the writer's reports for the past three years. It must be distinctly understood, however, that in the matter of expressed opinions no finality must be attached to them. With increased knowledge comes further enlightenment, and the writer acknowledges that he has seen reason in some cases to amend and modify opinions which were held three years ago. Similarly, it is only to be expected that in the course of a few years opinions respected at present will need further modification.

All that Research can do is to proceed carefully from point to point, re-modelling opinions, and enlarging its view-point as

further light is shed upon the subject. At the same time, in the course of our work certain definite facts have been arrived at, and as far as one can see these facts are immutable under existing circumstances.

One might point out the difficulties under which the Research Branch of the Rubber Growers' Association has laboured. First in the field more than three years ago, the results of its work have generally been in opposition to the market; but this and other points are so well known and appreciated by managers as a whole that there is no need to go further into the question. During the last twelve months, however, we have seen conditions gradually improving, and there can be no doubt that the Rubber Exhibition in New York last September has further enlightened rubber consumers as to the intrinsic value of plantation rubber. It is not too much to hope that the increase in knowledge will lead to a fuller appreciation of our rubber in the future.

For convenience in reference it is proposed to divide the work under the following sections:—

I. Field Operations.
II. Factory Operations.
III. Machinery and Buildings.
IV. The Finished Rubber.
V. General Discussions.

As the original scope of the Research work was to be confined to the preparation and curing of rubber, it will be seen that this publication makes no claim to be a full text-book upon Rubber. It is, and does not pretend to be other than, a book of reference for estate managers in the ordinary course of their work. For academic discussions on theoretical points of importance to planters the reader must refer to text-books.

These introductory remarks cannot be concluded without reference to the sympathetic support which the Local Committee and the Home Council have accorded the writer. They may be assured that his work has been lightened on innumerable occasions by their attitude.

All the vulcanisation tests and figures which appear in this work were supplied by our London chemists, Messrs. Clayton Beadle & Stevens.

SIDNEY MORGAN.

The Research Laboratory,
Petaling Estate,
Petaling.
June, 1913.

CONTENTS

PART I.—FIELD OPERATIONS

CHAPTER I

PLANTING AND THINNING OUT

CHAPTER II

TAPPING SYSTEMS

CHAPTER III

TAPPING AND COLLECTING

CHAPTER IV

TRANSPORT OF LATEX

CHAPTER V

GENERAL FIELD OPERATIONS

PART II.—FACTORY OPERATIONS

CHAPTER VI

PRELIMINARY TREATMENT OF LATEX

CHAPTER VII

COAGULATION

CHAPTER VIII

PREPARATION OF SHEET RUBBER

CHAPTER IX

PREPARATION OF CRÊPE RUBBER

CHAPTER X

DRYING OF RUBBER

CONTENTS

PART III.—MACHINERY AND BUILDINGS

CHAPTER XI

MACHINES

CHAPTER XII

FACTORIES

CHAPTER XIII

OTHER BUILDINGS

PART IV.—THE FINISHED RUBBER

CHAPTER XIV

DEFECTS IN CRÊPE AND BLOCK RUBBERS

CHAPTER XV

DEFECTS IN SHEET RUBBER

CHAPTER XVI

COMPARATIVE STRENGTHS

PART V.—GENERAL

CHAPTER XVII

CHAPTER XVIII

CHAPTER XIX

CHAPTER XX

CHAPTER XXI

THE PREPARATION OF PLANTATION RUBBER

PART I

FIELD OPERATIONS

CHAPTER I

PLANTING AND THINNING OUT

PLANTING DISTANCE AND YIELDS.

It is an easy task to criticise the actions of the pioneer planters of *Hevea Brasiliensis* in this country; and because of such ease the present-day critic is apt to condemn unduly the methods employed in the previous decade. Although we know a little more concerning the scientific questions involved in the distances of planting, the sum-total of that knowledge is but comparatively small and does not justify an assumption that matters could have been better regulated with a little foresight. In fact, our present knowledge does not preclude the possibility that future investigators may bring against us the charge which is now often levelled at the earlier planters. Most estates are now planted on what are called "wide-planted" lines, the distances ranging from 20 ft. by 20 ft. to 30 ft. by 30 ft., and even 40 ft. by 20 ft. In comparison with the old distances of 10 ft. by 10 ft. and 15 ft. by 15ft. these planting distances would seem to be amply wide; but we do not know but what, in the course of a few years, even 20 ft. by 20 ft. will be looked upon as much too close. Even now the number of planters who look upon 90 trees to the acre as the maximum number permissible is quite large.

No planter would wish perhaps, from choice, to return to the method of planting 15 ft. by 15 ft.; but at the same time there

B

was an apparently sound argument that until the estate had established its financial position it would pay to tap all the trees, eventually cutting out alternate ones so that the ultimate distance between the trees would be 30ft. by 15ft. Our present knowledge is not sufficient to determine on *a priori* reasoning whether such a course would, or would not, retard the growth of the trees generally. If it did, then it is probable, as advanced by some, that the tapping stage was reached later, and that had the trees been planted originally 30 ft. by 15 ft. the yields obtained eventually would have compensated for a comparatively smaller amount at the beginning due to a smaller number of trees per acre.

On this point no decided opinion can be given, as we have no statistics available. Arguing, however, from later observation and results obtained in the thinning out of over-planted areas, it would seem certain that there was truth in the suggestion.

On several estates managers have taken courage to thin out their more closely planted fields, with results which entirely justify their course of action. Some fields have been thinned by cutting out half the number of trees, and others by taking out a smaller number. It was noted that the yield from any particular field thus treated immediately diminished, as was only natural. It was not long, however, before a gradual increase was evident, and in the course of a comparatively short period (only six months in some cases) the yield was greater than that from the same area when it contained double the number of trees. Not only so; the remaining trees have increased in girth at a much more rapid rate than in previous years; they have put on larger crowns, and are healthier generally. This being so, it follows that the trees as a whole are better able to withstand the system of tapping imposed upon them, and that in future the yields will be proportionately larger. With these facts in mind no managers should be deterred from recommending that closely-planted areas should be thinned out at as early a date as possible consistent with practical economy. The longer the matter is delayed the greater will be the difficulties to be encountered in the work, and the longer will the remaining trees take to increase their yields.

MODES OF THINNING OUT.

In general there are only two methods of decreasing the number of trees to the acre. They are—

(*a*) By taking out alternate rows.

(*b*) By discriminate selection of trees.

There are arguments for and against either method, and circumstances must influence greatly the choice of methods. The argument chiefly brought against the latter method is that it gives an irregular appearance to the field, and that the order of working in tapping is seriously disturbed. One can easily understand that coolies used to working up and down regular rows of trees are more easily supervised. Moreover, in the case of bad tapping the fault can be allocated much more easily. It is possible, however, that undue importance is attached to these points, and that experience would find an easy solution to these difficulties. Apart from this consideration, there is a great deal to be said for the selection method under certain circumstances. Where the decision to thin a field comes at a very late stage it is obviously unwise to cut out alternate rows. In such fields there are always a number of trees which are much inferior to the others. It is quite possible that by taking alternate rows good trees would be marked for removal and the poor ones might remain. Under such circumstances thinning out by selection would be entirely justified, and cutting out alternate rows would be an unwise policy to pursue.

On the other hand, in the case of fairly young areas on which the growth has not had time to become markedly irregular the cutting out of alternate rows is likely to be successful, and all the difficulties in working the labour force will be obviated.

There has been no small amount of discussion recently as to whether, under either of the two systems of thinning, it is wise to cut out the marked trees to the roots at once or not. On some estates, it is the custom to pollard all marked trees and to continue to tap these tree-trunks for nine or twelve months before finally cutting them out. The main argument advanced in support of such treatment is that by this means the yield on that particular area suffers only a very gradual diminution. In the mean time the other trees will have put on extra foliage and will be so much improved that the recovery in yields will be much quicker than under the ordinary circumstances of outright thinning. Another view of the case is presented in the argument that by outright thinning so much actual rubber in the tree is absolutely thrown away; and that, therefore, there is no reason why the pollarded trunk should not be tapped heavily in order to obtain as much latex as possible from it during a short period. For this reason it is often found on estates that the alternate rows are being maltreated. Coolies are told that

wounds will not be noticed; that what they are to do is to get the latex from the trees. This obtains whether the trees have been pollarded or simply marked out for later removal. Some managers have swiftly recognised that these instructions are not wise. The coolies fall into careless habits, and their ordinary work suffers in consequence. It is found, on the whole, that if the marked trees are to be tapped the tapping must be as careful as is usual, if the work generally is not to suffer. Nevertheless, there can be no objection to these marked trees being used for teaching new coolies to tap, providing the faults are pointed out exactly as they would be under the best of circumstances.

One of the arguments advanced by an advocate of outright thinning against pollarding is that it encourages disease. He points out that *Fomes semitostus*, white ants, shot-hole borers, and other troubles will eventuate if the trunk is left in the ground for a year. It could be advanced, of course, that exactly the same argument would apply to outright thinning if the stump and roots are not taken out of the ground. These operations naturally cost money, but if the work is to be done well it must be done thoroughly. Expenditure in the present will prove to be economy in the future. There can be no doubt, however, that the outlay in taking away the stumps and roots will be more than compensated for many times by the increase in yields even in the first twelvemonth. Unfortunately, we have no actual figures to guide us in deciding which of these two systems of thinning fields is the better, and judgment can be based only upon argument and observation. Even were it possible to obtain such figures, in course of time we should probably find that the necessity for them no longer existed, as any cutting out of trees, if done at all, will be performed within the next few years.

CHAPTER II

TAPPING SYSTEMS

Of tapping systems operated or proposed there have been a large number during the last decade. The majority of these have been found wanting long ago, some have lingered in custom until recently, and a few are still in vogue. Mention of the small-V system, the irregular-V system, the single oblique-cut system, the spiral system, the paring and pricking methods, etc., makes history. It is not intended here to discuss these obsolete practices, and the reader desiring information is referred to published text-books which deal fully with them. Former systems.

The systems practised in this country during the past three years have varied from cuts over half the circumference of the tree which was tapped every day, to cuts over one-quarter of the circumference of the tree tapped every alternate day. Intermediate systems have been those in which cuts extending over half the circumference were pared every alternate day; those in which one-quarter or one-third of the tree is tapped every day, and those in which the basal-V on half the circumference of the base of the tree is re-opened either every day or every second day. More recent systems.

Of these some have already fallen into desuetude, and others are suspect. It is now acknowledged that tapping over half the tree every day, even with cuts well spaced apart, imposes too severe a strain upon the recuperative power of the trees. This is well borne out by experimental evidence which will be given later. The great problem in tapping which confronts any manager is to plan such a system which, while giving the best yield of latex, will enable him to conserve the bark of his trees and will not impose a strain upon the power of his trees.

Theory, experiment, and practice combine to show that these ends can only be attained by a system which *at most* does not exceed the *apparent equivalent* of tapping on one-quarter of a tree every day. Some managers still prefer to utilise one-half of the circumference, but only tap on alternate days. In some cases

this semi-circumference is made up of adjacent quarters, in others of opposite quarters. Whatever the system, however, the aim is, or must be, to plan it so that four years are occupied in removing the whole circumference of bark either one-quarter or one-half at a time. In other words, the period allowed for the renewal of any portion of bark before proceeding to tap it again must be four years. A few years ago this period for renewal was regarded as extremely conservative by a number of people, but practice has determined that even this interval will not be long enough for full and correct bark renewal on some areas. It must have been evident to experienced planters that on some of the older and even moderately wide-planted areas the renewal of bark in four years becomes increasingly poor in each successive cycle. At present we know of one estate on which, for this reason, the system of tapping has been changed to one-quarter tapped every alternate day. If the cuts are spaced fifteen inches apart, and calculating the removal of bark at eighteen cuts per inch, we see that the period of bark renewal has been raised to six years. In the opinion of some such a conservative system would be followed by a severe diminution of output. As a matter of fact the reverse is actually the case, and the output has increased. It is evident, therefore, that our present knowledge is likely to undergo extension and that the future trend of practice will be to increase the period of bark renewal in our present older trees; *i.e.* to adopt more conservative systems of tapping for these particular areas. At the same time, it may be pointed out, possibly such revision of methods will not be required with trees which are now being planted on wide-spaced lines.

The basal-V system stands apart from other systems because it is, in a large measure, only a temporary system. Initially it was introduced, we believe, because of its great value in tapping young trees which had not the necessary girth measurement higher from the ground to sustain other systems. It thus enabled one to bring an area into the tapping stage at an earlier date; and this was a great consideration when it is remembered that capital expenditure would be thereby diminished gradually. Even now on many well-established estates the system is in strong favour, and the writer sees no great objection to the system except from the difficulty to be encountered later when it is considered desirable to change to a system of tapping embracing single quarters or opposite quarters.

A system of tapping one-third the circumference of the tree every day has a little vogue, but as this only allows a period of three years for bark renewal it is bound to be superseded by a more rational system. Experienced planters who have tried it have recognised this, and the every-day tapping has given way to alternate day tapping with beneficial results. In its present form of allowing five to six years for bark renewal the system is one which should prove successful; but should it be decided at some future date to change to a system of quarters there will be great difficulty encountered in the actual operation of tapping, because the cuts will then run across bark of uneven renewal.

BUKIT RAJAH ESTATE EXPERIMENTS.

In order that some light might be obtained upon the effects of some tapping systems experiments were carried out by the writer on Bukit Rajah Estate some three years ago. The experiments ran for a period which was considered sufficiently long to bring out the points needing investigation, but it would have been of great advantage had it been possible to extend the period to a twelvemonth. A larger number of trees were employed than was usual in small experiments, and the conditions were absolutely identical. Furthermore, the whole of the work, both in the field and factory, was under the personal supervision of the writer; so that it can be claimed that the conclusions drawn are of actual practical value. Three hundred trees, all four and a half years old and not previously tapped, were taken in three sections. One section was tapped full herring-bone fashion (half the circumference of the tree) every day, another on the half herring-bone system (one-quarter of the circumference) every day, and the other half herring-bone every second day.

Aim of the experiment.

The tendency during previous years had been to tap trees heavily in order to obtain a maximum yield. This is usually considered chiefly with regard to the rate at which bark is removed. It is assumed generally that it is advantageous to tap the trees as heavily as possible provided sufficient time is given for renewal of bark to take place. There is, however, another consideration worthy of notice.

Assume that a tree is being lightly tapped, and that only every other day. Suppose we now begin to tap it more heavily, say by making twice the number of incisions, as by changing from a half herring-bone to a whole one, or by tapping every day. In neither of these cases shall we obtain twice the quantity of latex, and if we tap full herring-bone *and* every day we shall not

get anything like four times the quantity of latex obtained by tapping half herring-bone every other day. The deficiencies are considerable, and many planters are aware of this fact.

But what is not so widely known, perhaps, is that not only is the yield of latex disproportionate when we increase the number of incisions or shorten the period between consecutive tappings, but also that, in all probability, this deficiency of latex is accompanied by a small percentage of caoutchouc.

These tapping experiments were carried out, therefore, as an attempt to determine whether this probability does or does not become a fact. From a study of the daily figures and of the summary, it will be found, among other points of interest, that not only are the yields disproportionate between the three systems, but also that the percentage of caoutchouc in the latex is highest in the section having the lightest system of tapping, and lowest in that section on which the heaviest tapping was imposed. The object of the experiment has been attained, therefore; and in addition, other information as to yields, etc., may be derived from the tables of figures and charts of graphs.

Notes on the experiments.

The tapping was carried out on five cuts, single or double, made twelve inches apart. The reason for this method was that it was the common practice on estates at that time. Calculating on twenty tappings per inch of bark excised and 300 tappings to the year, it was expected that one quarter of the tree would last about eight or nine months. It undoubtedly would have been much better to have utilised only three cuts spaced eighteen inches apart so as to make one quarter last one year on daily tapping; or to have put four cuts fifteen inches apart so as to make one quarter last eighteen months on alternate day tapping. The actual number of tappings obtained per inch averaged twenty. Glass cups were used and no water was allowed in them. The coolies, however, were allowed to use a leaf stalk dipped into water for running down the main channel. The knife used was a small bent gouge.

In the several sections trees were lost. Section (1), which was tapped most heavily, lost two trees by white ants and one from the apparent effects of "shot-hole borers." As a matter of fact the three trees suffered primarily from *Fomes Semitostus*. In Section (2) one tree was lost by *Fomes Semitostus*, and Section (3) lost one tree by white ants.

Most serious, as regards the effect on the experiment, was the phenomenon of trees suddenly refusing to yield latex. This

was first noticed on the twenty-fourth day of tapping, and if reference is made to the chart of graphs showing the yields expressed in weight of dry rubber, or to the graph showing the relation between volume of latex and percentage of dry rubber, the fact is strikingly brought out. A few days later the number of trees yielding little or no latex had increased to twenty-five, and the number continually increased until, on the seventy-fifth day of tapping, there were fifty-three trees quite dry or giving practically no latex. There was no increase in the number up to the date of terminating the experiment. The dry trees were tapped as usual for some time, for experimental purposes, but at last tapping was abandoned, that is, consistent tapping. Trials were made at intervals but in no case was it found that a tree had recovered. All these trees were tested shortly before the experiment was concluded, and it was found that only one tree yielded no latex in any part. All the remainder yielded latex either above the tapping area or on the opposite half of the tree.

In view of the above facts attention is drawn to the figures relating to this Section given in the Summary and marked with an asterisk. These figures are based on the presumption that there were one hundred trees in the Section, whereas from the figures given above of diseased and dry trees, there were, at the end period of the experiment only forty-four trees yielding latex. This can be strikingly made clear by looking at Chart I of the graphs. Had one hundred trees been actually yielding latex, of course, the yield per tree per year would presumably have been higher. But, on the other hand, is it possible that the trees which were being so heavily drained would continue to yield latex? Does it not appear that the system of tapping was responsible for the drying up of the trees?

Although it is concluded that the system of tapping was responsible for this drying-up of the trees it should be borne in mind that, as the experiment was confined to virgin trees, it would not be applicable necessarily throughout the maturer life of the tree. It will be seen that the percentage of the dry rubber in the latex yielded by the remainder of the heavily-tapped trees was not appreciably less than in the case of the trees tapped on a more conservative system.

Weather conditions. In order that the manner in which the various sections behaved in similar periods may be observed, it is considered advisable to include the figures showing the full course of the

experiments. As may be seen, a note was made on each occasion when the weather gave signs of being out of the normal. In the opening period heavy rains were rather frequent, and it was observed that when heavy rain fell during the night and was followed by brilliant sunshine in the morning, there was an increased yield of latex accompanied by a decrease in the percentage of caoutchouc. Although record was kept of the occurrence of dull weather, an examination of the graphs fails to confirm the view of some planters that the trees give increased and more rapid yields on dull days than on normal days.

The wintering period occurred during the course of the experiment, and its course may be easily followed in the graphs. During that time the yields of latex in each of the three sections showed a gradual diminution, but although the actual yield of dry rubber per day was smaller, the percentage, as may be seen from Graphs 2A, 2B, and 2C, was high.

This leads us to a general proposition which may be deduced from a glance at the graphs. We see that the graphs of yield of latex and percentage of dry rubber do not coincide, but are in contrast. *When the yield of latex increases, the percentage of caoutchouc diminishes; and when the yield is low the percentage increases. A slight variation in the yield of latex is generally opposed by a marked rise or fall in the graph of caoutchouc percentage.*

It will be noted that in the three sections the percentage of caoutchouc in the latex was highest in the opening days of the experiment. It speedily fell and became normal, as the graphs show.

During a short period towards the end of the experiment, from the eighty-third to the eighty-ninth day, extremely hot and dry weather was experienced. The effect upon the yields was marked, but the percentage of dry rubber remained normal.

STATISTICS OF THE TAPPING EXPERIMENT.

Tapping Experiments, Bukit Rajah Estate. March to June, 1910 (Inclusive).

	Full herring-bone system tapped every day.				Half herring-bone system tapped every day.				Half herring-bone system tapped every other day.				
Days.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to vol. of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Remarks.
1	80	27·0	33·75	6·0	53	16·9	31·9	4·25	49	14·1	28·78	3·5	Trees have been tapped for the past three days.
2	89	27·81	31·14	4·5	45	15·75	35·0	2·5	—	—	—	—	
3	92	26·45	28·75	6·0	47	14·7	31·28	2·5	53	17·22	32·5	4·25	
4	124	33·06	26·66	3·0	77	24·39	31·67	3·5	—	—	—	—	Much rain overnight.
5	123	36·9	30·0	4·5	75	22·5	30·0	2·5	80	20	25·0	1·5	
6	125	37·5	30·0	4·5	96	22·4	23·3	2·5	—	—	—	—	Heavy rain overnight. Some rain in early morning.
7	—	—	—	—	—	—	—	—	—	—	—	—	Sudden heavy downpour: Cups overflowed: latex lost.
8	119	31·73	26·6	2·25	80	24·0,	30·0	2·5	—	—	—	—	
9	—	—	—	—	—	—	—	—	—	—	—	—	Heavy rain filled cups to overflowing.
10	168	37·8	22·5	2·0	94	22·5	23·0	1·25	—	—	—	—	Heavy rain overnight, followed by brilliant sunshine.
11	110	27·5	25·0	2·25	76	19·5	25·66	1·5	105	29·02	28·50	1·5	
12	112	23·2	20·71	3·0	76	20·25	26·65	1·5	—	—	—	—	
13	86	19·35	22·5	3·25	68	17·2	25·29	2·5	94	24·0	25·53	2·0	Slight rain in morning.
14	98	19·0	19·39	3·5	64	16·25	25·4	2·25	—	—	—	—	
15	64	14·4	22·5	3·0	62	14·85	23·95	2·0	86	18·5	21·51	1·5	
16	102	19·25	18·87	4·25	58	13·1	22·6	2·5	—	—	—	—	
17	88	18·77	21·33	2·5	70	15·4	22·0	2·5	100	19·0	19·0	2·25	Some rain during collection.
18	111	22·5	20·27	2·5	97	20·0	20·61	1·5	—	—	—	—	
19	104	20·8	20·0	2·0	84	19·72	23·48	2·25	96	19·12	19·91	2·5	
20	124	22·3	17·98	3·5	84	19·45	23·15	3·0	—	—	—	—	Do.
21	124	22·67	18·20	3·5	97	18·0	88·56	2·5	151	21·0	13·24	3·25	Do.
22	118	23·6	20·0	2·25	88	19·0	21·6	2·25	—	—	—	—	Dull weather.
23	60	11·25	18·75	2·25	58	14·9	25·7	2·0	68	14·97	21·72	2·5	About 12 trees in Section I. becoming dry.
24	69	13·25	19·20	3·5	62	13·11	21·14	3·0	—	—	—	—	

Days.	Full herring-bone system tapped every day.				Half herring-bone system tapped every day.				Half herring-bone system tapped every other day.				Remarks.
	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	
25	58	10·3	17·76	2·5	72	13·3	18·47	2·5	82	17·25	21·04	3·75	16 trees in Section I. nearly or quite dry.
26	—	—	—	—	—	—	—	—	—	—	—	—	Heavy rain in morning. Tapping stopped.
27	44	7·05	16·02	3·25	76	13·57	17·86	3·25	—	—	—	—	Dull weather.
28	34	6·27	18·44	1·0	54	11·27	20·88	1·5	66	14·5	21·97	1·5	25 trees in Section I. dry.
29	41	7·75	18·90	1·75	64	12·95	20·23	2·5	—	—	—	—	
30	42	8·2	19·52	1·75	56	11·3	20·18	2·0	68	15·4	22·35	1·5	Rain overnight.
31	36	6·94	19·28	1·0	54	11·45	21·2	1·75	—	—	—	—	
32	—	—	—	—	—	—	—	—	—	—	—	—	Heavy rain prevented tapping.
33	34	6·5	19·12	2·5	48	10·1	21·04	1·75	52	11·69	22·48	2·0	
34	46	8·48	18·43	2·0	54	10·07	18·65	1·5	—	—	—	—	Slight rain during tapping.
35	36	7·6	21·11	1·0	45	9·6	21·33	1·0	54	13·38	24·77	1·5	34 trees in Section I. dry or nearly so.
36	40	8·45	21·12	1·5	56	11·95	21·54	1·25	—	—	—	—	
37	32	6·12	18·81	2·25	48	10·4	21·66	2·5	56	12·46	22·25	3·0	
38	37	7·5	20·27	1·5	46	10·0	21·74	2·75	—	—	—	—	
39	34	7·92	23·30	2·5	48	10·7	22·29	2·25	56	13·99	24·98	2·25	
40	32	7·16	22·37	2·25	50	11·0	22·0	2·5	—	—	—	—	
41	—	—	—	—	—	—	—	—	—	—	—	—	No tapping. Heavy rains.
42	30	6·77	22·56	4·25	52	12·97	24·96	4·5	52	13·8	26·58	3·5	Rather dull.
43	—	—	—	—	—	—	—	—	—	—	—	—	Heavy rain prevented tapping.
44	36	8·3	23·06	2·5	54	13·15	24·35	3·5	—	—	—	—	
45	31	8·0	25·16	2·5	44	11·0	25·0	1·5	46	11·9	25·6	3·0	
46	32	9·01	28·12	2·75	53	12·45	23·5	2·25	—	—	—	—	
47	30	7·5	25·0	2·5	46	11·25	24·45	3·25	50	12·5	25·0	3·25	
48	41	9·55	23·29	2·5	56	12·95	23·12	2·75	—	—	—	—	
49	40	9·0	22·50	1·25	58	12·15	20·95	2·25	61	15·35	25·16	2·0	
50	39	9·05	23·20	1·5	61	13·66	22·39	2·0	—	—	—	—	
51	42	8·7	20·71	1·5	65	14·2	21·84	2·25	67	15·81	23·6	2·0	
52	42	9·77	23·26	1·25	57	13·7	24·03	1·5	—	—	—	—	
53	38	9·75	25·66	2·0	62	14·15	22·82	3·0	68	18·5	27·2	2·25	
54	39	8·82	22·61	1·5	74	14·81	20·01	2·75	—	—	—	—	
55	32	7·32	22·87	1·75	58	12·87	22·20	1·75	60	15·7	26·16	2·5	Rain early morning before tapping commenced.
56	42	9·5	22·62	1·25	68	16·22	23·85	1·5	—	—	—	—	
57	47	11·2	23·83	2·5	70	15·6	22·28	2·25	73	19·75	27·05	3·5	Dull morning.
58	45	10·13	22·51	2·0	69	16·5	23·40	1·5	—	—	—	—	
59	38	8·65	23·02	1·5	60	15·06	25·10	1·75	62	16·4	26·45	1·5	

Days.	Full herring-bone system tapped every day.				Half herring-bone system tapped every day.				Half herring-bone system tapped every other day.				Remarks.
	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	Volume of latex in fluid ozs.	Dry rubber content in ozs.	Percentage of dry rubber to volume of latex.	Weight of dry scrap in ozs.	
60	43	9·71	22·58	1·75	66	15·1	22·88	1·75	—	—	—	—	
61	45	10·69	23·77	2·0	66	16·22	24·57	2·0	79	22·0	27·85	1·5	
62	48	11·10	23·12	1·5	68	16·5	24·26	1·5	—	—	—	—	
63	34	7·51	22·09	1·25	70	16·20	23·14	1·5	77	19·7	25·58	1·25	47 trees in Section I. dry.
64	52	11·4	21·92	2·0	76	15·95	20·98	2·0	—	—	—	—	
65	—		—	—	—	—	—	—	—	—	—	—	Rain prevented tapping.
66	62	14·02	22·61	1·75	77	17·6	22·86	1·5	92	23·75	25·81	1·75	
67	52	11·4	21·92	1·5	72	17·1	23·73	1·75	—	—	—	—	
68	40	8·6	21·5	2·0	86	17·31	20.13	1·75	87	22·35	25·7	2·0	Some rain fell during collection.
69	43	9·42	21·9	1·5	76	17·3	22·76	1·5	—	—	—	—	Rain delayed tapping.
70	54	10·75	19·9	1·5	80	18·01	22·51	1·5	90	24·96	27·66	2·0	
71	52	11·5	22·11	1·75	80	16·75	20·94	1·75	—	—	—	—	
72	49	10·4	21·22	1·75	84	17·25	20·53	2·0	93	24·0	25·8	2·25	
73	50	11·63	23·26	1·5	86	17·67	20·54	1·75	—	—	—	—	
74	—	—	—	—	—	—	—	—	—	—	—	—	Rain prevented tapping.
75	41	10·25	25·0	1·5	80	17·45	21·81	2·0	98	23·75	24·22	2·25	
76	50	11·1	22·2	1·75	74	16·57	22·39	1·5	—	—	—	—	Slight rain; did not interfere with collection.
77	46	10·9	23·69	1·75	76	14·31	18·83	2·25	92	22·75	24·72	2·0	
78	50	10·7	21·4	1·75	78	17·45	21·81	1·5	—	—	—	—	53 trees in Section I. dry or nearly so.
79	42	9·5	22·62	1·5	76	15·37	20·22	1·75	96	22·4	23·33	2·5	Rather dull morning.
80	48	10·9	23·12	2 25	72	15·45	21·46	2·0	—	—	—	—	
81	48	11·18	23·29	2·5	74	15·6	21·08	2·0	94	21·87	23·25	1·75	
82	—	—	—	—	—	—	—	—	—	—	—	—	Torrential rain in early morning.
83	56	11·94	21·32	1·75	84	18·2	21·66	1·5	—	—	—	—	
84	54	11·8	21·85	2·0	60	12·85	21·41	1·25	92	22·20	24·13	1·75	
85	44	10·1	22·95	2·25	74	15·43	20·85	1·75	—	—	—	—	Dazzling sunshine.
86	41	8·31	20·27	1·75	56	11·7	20·9	1·75	76	18·25	24·01	1·5	Extremely hot.
87	37	8·72	23·57	2·25	62	14·4	23·22	2·5	—	—	—	—	
88	36	7·93	22·03	2·75	58	11·85	20·43	1·75	70	16·95	24·21	2·25	
89	40	9·05	22·62	2·0	80	16·37	20·46	2·25	—	—	—	—	Heavy rain storms last evening and night.
90	40	7·95	19·87	1·75	80	19·0	23·75	1·5	78	16·25	20·83	2·0	Do. Trees wet.
91	56	10·57	18·87	1·5	82	16·8	20·48	1·5	—	—	—	—	Rain prevented exact collection of latex.

SUMMARY.

	Whole herring-bone tapped every day.	Half herring-bone tapped every day.	Half herring-bone tapped every other day.
Total volume of latex, per section.	4833 fluid ozs.	5542 ozs.	3069 ozs.
Total yield of dry rubber, per section (excluding scrap).	68·27 lbs.	78·87 lbs.	46·09 lbs.
Average yield of dry rubber, per tapping for each section (excluding scrap).	0·831 lbs.	0·962 lbs.	1·152 lbs.
Average percentage of dry rubber, per tapping, for each section (excluding scrap).	22·21 per cent.	22·88 per cent.	24·38 per cent.
Calculated average yield of dry rubber, per tree, per year of 300 tapping days (excluding scrap).	*2·496 lbs.	2·886 lbs.	1·728 lbs.
Total scrap rubber (dry), per section, for period of experiment.	11·78 lbs.	10·81 lbs.	5·65 lbs.
Calculated average yield of dry rubber per tree, per year (including scrap).	*2·927 lbs.	3·281 lbs.	1·94 lbs.
Calculated yield per acre per month, taking 120 trees to the acre (planted 20 × 18) without scrap.	*24·96 lbs.	28·86 lbs.	17·28 lbs.
Ditto, with scrap.	*29·27 lbs.	32·81 lbs.	19·40 lbs.

* These figures cannot be taken as correct, being based on a supposition. For explanation see remarks on Section I. in Notes on Experiments.

CHART OF THE FIRST SECTION OF THE TAPPING EXPERIMENT.

Chart illustrating yield of latex in fluid ounces and percentage of dry rubber per tapping. Whole herring-bone system tapped every day.

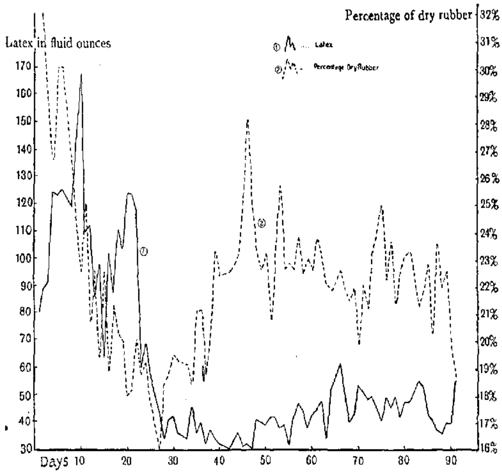


CHART OF THE SECOND SECTION OF THE TAPPING EXPERIMENT.

Chart illustrating yield of latex in fluid ounces and percentage of dry rubber per tapping. Half herring-bone system tapped every day.

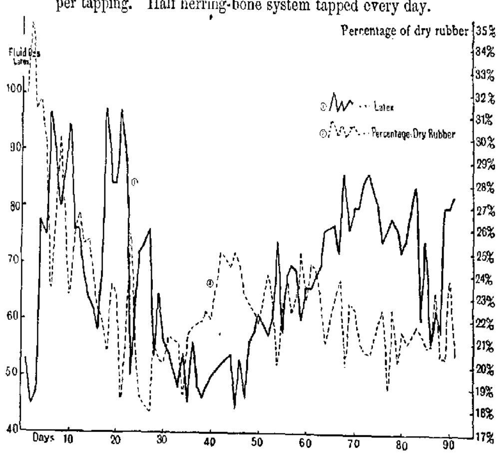


CHART OF THE THIRD SECTION OF THE TAPPING EXPERIMENT.

Chart illustrating yield of latex in fluid ounces and percentage of dry rubber per tapping. Half herring-bone system tapped every alternate day.

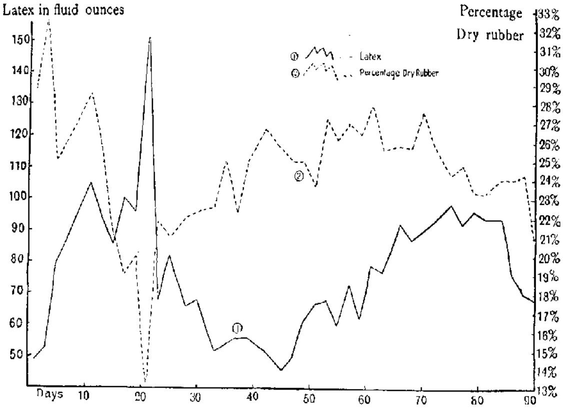
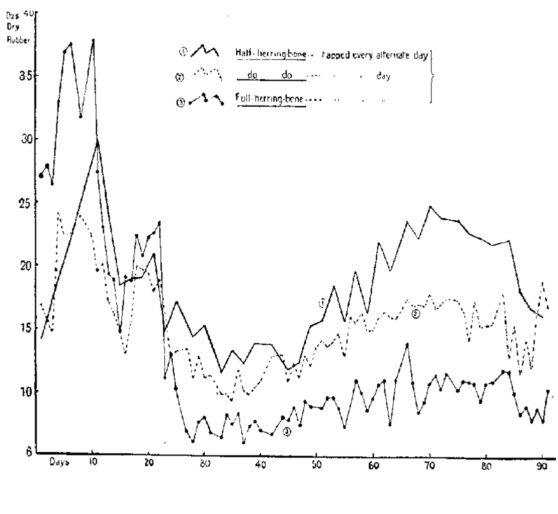


Chart illustrating yields of dry rubber in ounces per tapping obtained under different systems of tapping.



Looking at the results of the experiments from the point of view of their respective values as systems of tapping to be avoided or to be adopted, it must be remembered that the trees were only being tapped for the first time; and that what may be a good and moderate system for trees of more mature growth would probably prove quite unsuitable, and likely to do a great deal of harm, to younger trees. On the other hand, a system which would put quite the maximum strain on young trees would probably be an injudicious system to employ on older trees, in that these trees might be capable of giving larger yields without sustaining hurt. Comments upon results.

So much has been said and written recently of the comparative values of those systems of tapping which cut across half the circumference of the tree in contrast with those which only take one quarter of the circumference, that it only remains to be said that the concensus of opinion and the outcome of the scientific study of the question goes in favour of quarter-tapping, as interfering less with the downward transport of organic material towards the base of the tree. It is necessary to remember, when tapping for the first time, that trees which at the commencement of tapping were by no means large or thick must become larger, in order that their latex systems may develop and yield continuously remunerative quantities of latex. The advantages of such a lenient treatment of young trees for the yield of future years certainly will outweigh greatly the advantages of a quick yield, which, after all, by reason of injury to the tree, may only be of short duration.

Such a truth is evident in the present experiments. The full herring-bone system for tapping young trees, judging by the results of the experiments, stands condemned as being too heavy. It is inferred from the drying-up of half the trees that the drain upon their reserves was too sustained and too exacting. Of the other systems, employing the half herring-bone on a quarter of the tree, that in which the trees were tapped on alternate days certainly gives the best results. Contrasting its figures with those of the same system tapped every day, it is not found that the latter gives twice the volume of latex, nor twice the quantity of dry rubber. On the contrary, the yield of dry rubber per tapping is higher in the alternate day system than in the every-day system; we see also that the average percentage of dry rubber to volume of latex is distinctly higher in the former than in the latter system. Of course, as may be seen

at a glance, the every-day tapping system shows the higher figures in calculated yields per year, and in calculated yields per acre per month. But here again the figures in column 2 are not nearly twice as large as those in column 3, as might be expected.

As regards the relative merits of tapping a quarter-tree every day and every alternate day, it is to be noted that, under both systems, the trees were in a normal and healthy condition at the end of the experiments; but that while the every-day tapping system naturally gives a higher yield of dry rubber for the whole period, the alternate-day system gives a higher yield of dry rubber per tapping and also shows a higher percentage of dry rubber in the latex.

QUALITY OF RUBBER FROM DIFFERENT TAPPING SYSTEMS.

One of the further aims of the experiment was to investigate the point as to whether the system of tapping had any effect upon the final quality of the vulcanised rubber. For this purpose the latex was made into sheet form each day and air-dried. At the same time sheets were taken from each section and smoke-dried. So that eventually four batches were obtained:—

1. Air-dried sheet from section tapped one quarter-tree every alternate day.
2. Air-dried sheet from section tapped one quarter-tree every day.
3. Air dried sheet from section tapped one half-tree every day.
4. Smoked sheet average from the three sections.

These samples were vulcanised under uniform conditions, and all were tested against:—

5. Average smoked sheet: ordinary estate production.

The Admiralty Tests gave the following results:—

	1	2	3	4	5
Percentage recovery in half an hour .	92·7	92·3	92·1	94·3	93·7
Percentage recovery in six hours . .	94·0	93·6	93·5	95·2	95·0

From these figures it will be apparent that any differences in the quality of the three unsmoked batches of sheet are very small. The rubber from that section of trees most lightly tapped showed an exceedingly small superiority; but on the whole there is very little to choose between the three samples; from which it would appear that the system of tapping the trees has little or no effect upon the quality of the rubber.

A much-vexed question was settled by the results obtained from sample 4. At that time there seemed to be considerable

difference of opinion as to whether the smoke-curing of rubber, as carried out on a small scale in this country, had any effect upon the quality of the finished rubber. By most it was maintained that superficial smoking, as it was styled, could not possibly cause any improvement. Yet it is here shown that a batch made of average sheet taken from the three sections proves to have been much superior, not only to the three parent samples of air-dried rubber, but also to the average production of smoked sheet from older trees on the same estate. In the latter instance, no doubt, the extra care and supervision which it was possible to give to the preparation of the experimental samples was a considerable factor in determining the difference. A point which should receive much consideration is that the conditions under which the samples were prepared and vulcanised were so even as to give the greatest weight to the results obtained. And as these were the first strictly comparative tests carried out, they represent the foundation upon which our continuous work in establishing the just position of plantation rubber was built.

EXPERIMENTS AT KUALA LUMPUR.

Tapping experiments on several systems were made at the plantation of the F.M.S. Department of Agriculture from the beginning of February, 1911, to the end of January, 1912. For the description of the experiments and the figures extracted the writer is indebted to the *Agricultural Bulletin* for September, 1912. It is to be regretted that an unfortunate selection was made in choosing the trees for experiment. The soil on which they grew had been under cultivation for years previous to the planting of rubber trees. The growth of the trees apparently had suffered in consequence, and, at the beginning of the experiment, although they were seven years old, their average girth was only 21 inches at 3 feet from the ground; *i.e.* they were in appearance only equal to normal trees about 4½ years old. In addition, they suffered from the disability of close planting, being only spaced 16 ft. by 16 ft. It will be seen, therefore, that for purposes of drawing analogies from the experimental trees with normal plantation trees the results on the whole, however valuable otherwise, can be only of small value. The experiments were carried out on sections of sixty-five trees each and embraced the following systems:—

Experiment I.—A quarter circumference of the tree tapped every day; two cuts 18 inches apart; twenty cuts per inch of bark removed.

Experiment II.—Two adjacent quarters of the tree tapped every alternate day, herring-bone system; two cuts 18 inches apart; twenty cuts to the inch.

Experiment III.—Two adjacent quarters of the tree tapped every day on the V system; twenty cuts per inch. One V at a height of 36 inches from the ground.

Experiment IV.—Two adjacent quarters of the tree tapped every alternate day on the V system; twenty cuts per inch. Two V's 18 inches apart.

Experiment V.—Opposite quarters of a tree, every day tapping. One cut on each quarter at a height of 3 ft. from the ground; twenty cuts to the inch.

Experiment VI.—Opposite quarters of a tree, tapped on alternate days. Two cuts on each quarter 18 inches apart; twenty tappings per inch of bark.

While these experiments had been planned to yield com parisons between several systems it seems a pity that no provision was made for obtaining information concerning the effect of frequency on one and the same system of tapping. Again, it should be pointed out that between any two systems of tapping, such as Expt. I. and Expt. III., in which use is made of systems tapping at a height of 18 inches from the ground and 36 inches from the ground respectively, there can be no comparisons for the first twelvemonth. This will be obvious from the fact that one system cuts across the bark at the base of the trunk, and hence the flow of latex is greater and richer, while the other will not come down to the same level for one year. In any case, the writer is unable to see any value in such an experiment as No. III. or No. V. from a practical planter's point of view. As already pointed out, where there is only one cut on a quarter tree at height of 36 inches from the ground, whether the system is single quarter, adjacent quarters, or opposite quarters, the first year's figures of yields cannot be placed in comparison with figures obtained from systems which cut across the lower bark during the first year. One cannot imagine any practical planter deliberately choosing any such system in which the lowest, or only, cut was at a height of 3 feet from the ground with virgin bark below that height. Bearing these points in mind, the figures of yields under each system may be studied.

EXPERIMENT I.

SINGLE-QUARTER TAPPING, EVERY DAY. TWO CUTS 18 INCHES APART.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	3	7	1	0½			1·58	
March	4	2½	1	4			10·88	
April	3	1	1	0½			15·89	
May	7	2	1	6½			3·04	
June	6	1½	1	10			1·97	
July	6	5	1	14			2·43	
August	12	11½	2	3½			6·05	
September	14	13½	2	2			7·05	
October	16	0	1	9½			16·77	
November	18	0	2	1			12·25	
December	18	7	2	5½			11·06	
1912.								
January	14	15	2	0½			4·76	
Totals	125	2½	20	9½	11	13½		65

EXPERIMENT II.

ADJACENT QUARTERS, HERRING-BONE SYSTEM, ALTERNATE DAY TAPPING. TWO CUTS 18 INCHES APART ON EACH QUARTER.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	4	1	0	8½				
March	4	1½	0	11½				
April	5	15	0	12				
May	9	2½	0	14				
June	6	1	1	5				
July	7	15½	1	6			As in	
August	8	9½	1	10½			Expt. I.	
September	7	9½	1	4½				
October	10	11½	1	4½				
November	12	5½	1	6				
December	11	9	1	4½				
1912.								
January	11	10½	1	5½				
Totals	99	12	11	12½	12	3½		65

EXPERIMENT III.

ADJACENT QUARTERS, EVERY-DAY TAPPING. ONE V AT A HEIGHT OF 36 INCHES FROM THE GROUND.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	3	13½	1	1½				
March	3	4	1	3½				
April	3	12½	1	4				
May	6	8½	1	7½				
June	6	12	1	12½				
July	7	7	2	5½			As in Expt. I.	
August	9	9	1	15½				
September	8	11½	1	10½				
October	9	4	1	13				
November	11	5	1	11½				
December	12	1	1	13				
1912.								
January	11	5½	1	14				
Totals	93	13½	20	00	12	4½		65

EXPERIMENT IV.

ADJACENT QUARTERS, ALTERNATE-DAY TAPPING. TWO Vs 18 INCHES APART.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	3	3½	0	10½				
March	3	4½	0	9½				
April	5	9½	0	8½				
May	7	15½	0	15				
June	7	2½	1	6½				
July	6	12½	1	6			As in Expt. I.	
August	9	12½	1	8½				
September	8	2	1	3				
October	10	1½	0	14½				
November	10	7	1	2½				
December	10	1	0	15½				
1912.								
January	13	5	1	2½				
Totals	95	13	12	6½	12	15		65

EXPERIMENT V.

Opposite Quarters, Every-Day Tapping. One Cut on Each Quarter at a Height of 36 Inches.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	3	9½	1	3½				
March	2	7	1	10				
April	3	5	1	1½				
May	5	6½	2	1				
June	4	9	2	6½				
July	5	3	2	4½			As in	
August	9	15½	2	7½			Expt. I.	
September	7	12	2	1				
October	9	1½	1	14				
November	13	2	1	14				
December	11	8½	1	11½				
1912.								
January	15	0½	2	0				
Totals	90	6	22	11	15	15½		65

EXPERIMENT VI.

Opposite Quarters, Alternate-Day Tapping. Two Cuts on Each Quarter 18 Inches apart.

Month.	Latex rubber.		Scrap rubber.		Bark shavings.		Rainfall.	No. of trees.
1911.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	inches.	
February	2	13½	0	12½				
March	2	7½	0	13				
April	1	13½	0	15½				
May	4	10	1	7½				
June	3	10½	1	11				
July	2	11½	1	12½				
August	5	7	1	11½			As in	
September	9	6	2	0			Expt. I.	
October	12	6	1	8				
November	10	6½	1	4½				
December	9	6	1	5				
1912.								
January	9	4½	1	7½				
Totals	74	6½	16	14½	15	11		65

The comments given by the official in charge of the experiments are as follows:—

It would be seen from the tables that the quarter-tree system with superimposed cuts of 18 inches tapped every day (Expt. I.), gave a considerably larger yield of latex than any of the others, while opposite quarters tapped on alternate days gave a poorer yield than any of the other systems.

It is noticeable in the experiments that the trees tapped every day, in each case, gave a larger yield than those tapped on alternate days. The difference in the yields of scrap rubber is particularly evident.

In Experiments I., III., and V., in which the trees were "tapped every day the results obtained are not strictly comparable, because where, as in Expt. I., the tapping cuts have extended at the end of the year's experiment to the base of the tree, in Expts. III. and V. the upper 18 inches only have been tapped. Consequently in the latter two cases there remains an untapped area of bark at the base of the trees which, according to what is generally supposed, gives a bigger yield of latex than any other part of the trunk. When, however, the results of the second year's tapping are obtained, it will be possible to draw more accurate conclusions as to the relative yields of the systems."

The chief point of interest in these results is the marked inferiority of the yields as given for Expt. VI. in which opposite quarters were tapped on alternate days. It is extremely difficult to see on *a priori* grounds why there should be such an inferiority, especially in comparison with the results of Expt. I. in which the system of tapping (one-quarter every day) is usually regarded as an equivalent to two opposite quarters tapped every alternate day, as far as the removal of bark is concerned. Again, quite a number of estates in this country have at one time or another changed from other systems to that of "opposite quarters every alternate day" as the outcome of practical experience. We have not heard that the yields have suffered in any way. One estate has, to the knowledge of the writer, been tapping all its medium and old trees on this system for many years, and it is a fact that the yield per tree per annum and the yield per coolie per day is extremely high in comparison with those of neighbouring estates working under other systems. We look forward

to the results of the second year's tapping, therefore, with considerable interest.

Last year some results were published of tapping experiments, carried out continuously during the years 1908, 1909, 1910, and 1911, by Bamber and Locke at Heneratgoda. At that time these results were regarded by many as epoch-making, and they are well worth attention. Here, again, we have to note that the trees experimented upon were abnormal in planting and growth, so that the conclusions drawn from the experimental results are necessarily untrustworthy as far as one would wish to make deductions concerning normal rubber trees. The experimenters chose seventy old trees (over twenty years of age) planted 12 ft. by 12 ft. We are not told much of their history, except that the previous tapping had been irregular. These seventy trees were divided into seven sections of ten each. The rows were numbered from I. to VII. and tapping was carried out on the same system in each row except that the intervals between successive tappings were different. RECENT CEYLON EXPERIMENTS.

The following table shows the average interval in days between successive tappings and the number of years allowed for renewal on the system adopted:—

	I.	II.	III.	IV.	V.	VI.	VII.
Interval . . .	1·4	2·6	3·9	5·1	6·5	7·8	9·0 days.
Period of renewal .	2·3	4	6	7	8	9	10 years.

The average yield per tapping of ten trees is given in grammes in the following table, which covers the last six months of 1908 and whole of 1909–10–11. During the whole of this time the experiment was carried on without a break.

AVERAGE YIELD PER TAPPING.

	I.	II.	III.	IV.	V.	VI.	VII.
1908 . . .	100	107	148	158	169	210	163
1909 . . .	57	72	86	91	113	121	108
1910 . . .	53	69	67	96	118	115	115
1911 . . .	—	37	78	143	169	176	154

One of the best yielding trees in row III. had unfortunately to be cut out early in 1910 owing to canker. No allowance is made for this fact in the above table, but in the table which follows one-fifth of the actual yield is added to the yield for row III.

It was obvious early in 1910 that some of the weaker trees of row I. had suffered from the rate at which they had been

tapped, and it was not thought desirable to continue operations on the renewed bark.

Now it might be thought possible to draw the conclusion at once from the above table that the yield of rubber per tapping increases directly with the interval between successive tappings up to an interval of eight days (row VI.). But it has to be remembered that row I. is always in a later stage of tapping than row II., and so on; whilst down to the end of 1910 the earlier tappings give in all cases higher yields than the latter ones. Towards the end of 1911, however, the yields began to increase. This increase was much greater in the case of the rows tapped at longer intervals. The following table shows the yields for January and February, 1912:—

PERIOD OF SIXTY DAYS, JANUARY AND FEBRUARY, 1912.

*Groups of Ten Trees.**

	II.	III.	IV.	V.	VI.	VII.
No. of tappings . . .	24	17	12	10	8	7
Total yield, grammes . .	1932	1540	2080	2163	2020	1572
Average per tapping . .	80	90	173	216	252	224

The average yields from rows V., VI. and VII. for these two months are greater than any yields previously obtained from rows I., II. and III.

From the above table the remarkable fact appears that after three and a half years' steady tapping (making full allowance for the fact that row III. contains only nine trees), rows IV., V. and VI. each yielded a larger amount of actual rubber, from 12, 10 and 8 tappings respectively, than rows II. and III. from 24 and 17 tappings respectively.

Turning to the figures for 1909–11 it is of interest to record approximately the crop per acre which the yields recorded would produce. The result, expressed in lbs., is as follows:—

AVERAGE ANNUAL CROP PER ACRE.

	II.	III.	IV.	V.	VI.	VII.
1909–10 . . .	566	480	381	364	315	257
1911	653	620	605	565	490	360

Now the yield for 1911 has increased over the average yield for 1909–10 in every case, but the increase is decidedly greater in the case of the rows tapped at longer intervals. Expressed as

* Allowance is made for the fact that row III. contains nine trees only.

percentages of the average yields for 1909–10, the increases are as follows:—

II.	III.	IV.	V.	VI.	VII.
17	29	59	55	56	38

In view of the figures for January and February, 1912, the conclusion presents itself that we are rapidly approaching a period when the crop gathered once a week will exceed the crop gathered every three or four days. According to the figures so far available, an interval of six and a half days (row V.) appears likely to give the best final result. All the tables here given show a distinct falling off in the case of row VII., indicating, as might have been expected, that nine days is too long an interval. The best yield per tapping is given throughout by row VI., and the best total yield for January and February, 1912, by row V. To revert to the subject of the early part of this article, if these were the only facts available, we should be justified in recommending a period of renewal of eight years as superior to one of four years.

We do not wish to labour this point too far, as it is desirable to know the further course of the experiment before coming to a final conclusion.

It must not be forgotten that the present experiment was made upon trees upwards of twenty years of age, planted at a distance of only 12 ft. by 12 ft. The facts are, however, remarkable, and of such importance that it seems desirable to place them at once in the hands of the public. There can be no doubt that the facts so far available point to the desirability of an increase in the interval between successive tappings.

Whatever we may think of the Ceylon experiments, which the writer has followed for some considerable time, the point which should have been emphasised much more strongly than was the case, is:—

"The yield *for a given period* was greatest at first from the trees tapped at frequent intervals. The relative yield from the trees tapped at longer intervals gradually increased until, *after three and a half years' continuous tapping*, the yield from trees tapped once a week *may, at a particular season*, become as great or greater than that from trees tapped at shorter intervals."

As far back as January, 1911, the writer had reported upon these experiments to his local committee of control, and through

them to managers. The tapping experiments had then been in vogue for about eighteen months. In the circular then issued the experimenters remarked that the trees were upwards of twenty years old, planted 12 ft. by 12 ft., and had not been previously tapped with any regularity. Further, they were beginning to show signs of the ill-effects of close planting. We were not informed then what system of tapping was employed, but it was remarked that "the system employed is one which is not recommended for practical estate work, as it was made rather drastic in order to test the endurance of the trees."

[Later we are informed that the original system was that of "paring and pricking." *After three years of this system* (*i.e.* in June, 1911) only do we find a saner method brought into practice.]

The principal conclusions then drawn by the experimenters are worthy of comparison with the more recent deductions. They were:—

1. Taking the first 40 tappings of each series, there is no sensible difference in yield which can be ascribed to the length of interval between successive tappings. The yield from trees tapped daily and from trees tapped weekly is practically identical *for the same number of tappings*, both in the gross and in proportion to the area of bark removed.
2. During the first few tappings the percentage of dry rubber obtained from the latex falls, the fall being more rapid as the tappings succeeded each other at short intervals. Sooner or later a nearly constant percentage composition of the latex is obtained. In the case of trees tapped at shorter intervals this level is lower than in the case of trees tapped at longer intervals.
3. Following naturally from the preceding statement, it was found that the proportion of scrap rubber obtained is lower in the case of more frequent tappings.
4. The trees tapped daily for eighteen months continue to afford a profitable yield of rubber. After giving over 7 lbs. of rubber per tree during this period, the average yield at the 440th tapping was at the rate of 4 lbs. of dry rubber per tree annually. The trees, it is stated, are quite healthy and show no signs of having suffered from severe tapping.

5. It is apparent, therefore, that frequent tappings are to be recommended from a practical point of view so far as more yield is concerned, but the removal of bark is more rapid. On the quarter system this is of less importance. The experimenters think that it still remains to be determined whether, of two systems, it would not pay better to tap daily through certain months and rest the trees (presumably in the dry season), or only to tap at longer intervals during these months when the flow of latex is less than ordinary.

The writer's comments in January, 1911, include the following remarks :—

"One would like to know what system of tapping was employed, and it would be pertinent to inquire why trees of such an age were selected for the experiment. Why were not younger trees taken? What we want to know is how far it is possible to tap our young trees so as to obtain the maximum yield with the minimum expenditure of bark, and with the future productiveness of the trees always in mind. The chief point of interest emerging from the experiments' conclusions is the fact that, comparing the first forty tappings of each series, whether 40 daily tappings or 40 weekly tappings, there seems to have been no sensible difference in yield [of latex, we presume] which can be accounted for by the length of the tapping interval. Being rather curious to know how this conclusion compared with the results obtained in the tapping experiments carried out at Bukit Rajah Estate in 1910, the first 40 tappings were taken of the trees which were tapped half herring-bone on quarter-tree, one section being tapped daily and the other on alternate days. I find, comparing either the yields of latex or the total yields of dry rubber, that the alternate day system has the advantage. The total yield of latex obtained in 40 daily tappings was 2585 ozs.; while that obtained in 40 alternate-day tappings was 3069 ozs. The gross weight of dry rubber obtained from 40 daily tappings was 44·04 lbs., while the 40 alternate-day tappings yielded 50·74 lbs. These weights included lump and tree-scrap as in the Ceylon experiments. It must be remembered, of course, that the period covering 40 alternate-day tappings covered twice the time occupied in 40 daily tappings. This point apart; we see that the results obtained in my experiments do not agree with those of the Ceylon experiments, and certainly show an advantage in favour of alternate day tapping when an equal number of tappings is taken. It must be remembered that in the Bukit Rajah experiments young trees of 4½ years

were tapped, in contrast with the 20-year-old trees at Heneratgoda; and, further, that batches of 100 trees were taken as against batches of 10 in Ceylon. It might be suggested that the advantage shown by tapping young trees every second day as against every day would diminish as the trees become more mature, but that is extremely doubtful."

Discrepancy between Ceylon results and results in Malaya.

These remarks, written when the Ceylon experiments had been running for eighteen months, are still instructive as showing how the interpretation of the results then arrived at has been very strongly modified in the more recent publications of Bamber and Lock. It is to be noted that even then there was some discrepancy between their results and results obtained by Ridley at Singapore and the writer at Bukit Rajah. Possibly the factors of close planting, older trees and a very severe system of tapping were responsible for the differences observed; but it is evident that as far as tapping young trees on a conservative system was concerned, no reliance was to be placed on the observed results at Heneratgoda.

Can reliance be placed upon the recent results?

The writer has now had an opportunity of studying Bamber and Lock's bulletin of September, 1912, concerning these tapping experiments, and as a result he desires to record his opinion that, as far as the practical planting industry in Malaya is concerned, the results of the Ceylon tapping experiments are not of such a nature as to induce anyone to place reliance upon the conclusions drawn therefrom. Regarded as academic facts having no immediate application at present, the experiments are very interesting and instructive, but it would be unwise to attempt to apply the deductions to our plantations. In support of this view the following points are worthy of note as being factors which render of no value any comparisons between the experimental plots and large plantations.

Important points to note.

1. The trees were all upwards of twenty years old, and had been planted 12 ft. by 12 ft. We are not given their history, but we are told that they had been tapped irregularly.

2. The root systems must have become interlaced to a considerable extent, and it is safe to assume that the soil had become impoverished. In point of fact, we were told in the beginning of 1911 that the trees showed signs of the effects of close planting.

3. The number of trees taken in each experiment was, unavoidably, too inadequate.

4. The method of tapping employed for the first three years

was extremely severe for closely planted trees, and the system of tapping was also very heavy. Before June, 1911, the trees were pared with the Bowman-Northway knife, and immediately pricked with a sharp-pointed spur pricker. Speaking of the effect of this method the experimenters confess :—

"In fact, several trees in rows I. and II. of the present experiment were showing signs of injury which are believed to have been occasioned partly by the method employed."

"The new method of paring only was followed by a marked increase in yield towards the end of 1911."

The system of tapping was as follows :—The bark to a height of six feet was divided into four equal parts each extending half-way round the tree. Each area was occupied by three V-shaped cuts. [It will be seen that each section contained three V's one foot apart.] The four areas were tapped in succession—first the lower half on one side, then the lower half on the opposite side, followed by the two upper areas in the same order.

5. It can be readily calculated that in the case of daily tapping all the bark to a height of six feet had been removed, and the first area was supposed to be ready for re-tapping, in two to three years. This, in combination with the *method* of tapping, would seem to be absurd in the light of *present* knowledge. Not only so, but we are unable to make any legitimate comparisons between the daily tappings in this series of experiments and the tappings at longer intervals, because we know that the trees tapped daily were maltreated and had no chance to show what might happen had the tapping been better planned.

6. Even in the rows tapped at intervals of 2·6 days and 3·9 days (averages) and having an estimated period for bark-renewal of four and six years respectively, it is perfectly obvious that the method of tapping and system of tapping, in combination with the other factors of age and close planting, were too heavy for the trees—in other words the trees were being overtapped. This is brought to light by the fact that *the yields from the second area of bark excised were less than from the first area.* Judged by this standard even the trees tapped every fifth day (seven years bark renewal) suffered slightly from the tapping method and system, in combination with the effect of close planting. The experimenters remark :—

"It is probable that the overtapping of row III. is associated with the poverty of the trees and their crowded condition; for the interval allowed for renewal in this case in six years, a period which would be undoubtedly ample for trees which were widely spaced."

7. The authors in another place make the remark that—

"In fact the most important point which appears in all the tables is the increased yield from the trees tapped at longer intervals, an increase which becomes apparent after tapping has continued steadily for a considerable time."

The writer would suggest that it is unfair to state such facts without taking into consideration that here the trees tapped at longer intervals are being compared with trees which are being confessedly overtapped. One is not warranted in applying such a deduction to our plantation trees without having made experiments on rational lines.

Other points of interest.

A few extracts from the bulletin are of interest and may be worth quoting:—

Loss of Bark.

"As the interval between successive tappings increases the number of cuts possible on a given area falls off steadily. Although the irregularity in the thickness of the bark shavings removed was unfortunately considerable, it is probably safe to ascribe to the drying up of the bark some part of the increase in the thickness of the shavings. This desiccation takes place to a greater extent when the interval between successive tappings is extended."

Poor yields per tree per annum.

"Allowing 270 trees to the acre (trees planted 12 ft. by 12 ft. with 11% of vacancies), the annual yield per tree varied from 1·2 lbs. with tapping at intervals of 9 days to 2·85 lbs. with tapping at intervals of 1·4 days. These yields, of course, are extremely small for such old trees, owing to the close distance of planting."

Overtapping.

"A satisfactory definition of overtapping has still to be devised. . . . Overtapping may be measured either by removal of bark or by removal of latex. It is usual to discuss only the former kind of loss in this connection, but a tree can be undoubtedly overtapped by pricking. In many systems of pricking only, the damage to the bark is at least as great as in the case

of paring, and with the best possible pricking some damage is inevitable. . . . In the present experiment row I. and some of the trees in row II. may be said to have been overtapped, because the whole of the bark has been removed up to the greatest height convenient for tapping, and renewal of the first and second areas is still imperfect. The result is probably due in part to the use of the pricker, and the bark might have shown perfect renewal if the method of paring had been employed from the beginning.

"From the evidence of the present experiment we are inclined to extend the idea of overtapping, and to assert that a tree may be overtapped although there is a considerable area of original bark available for tapping. If the yield from the first area is not improved upon, or equalled, by the yield from the second area the tree is being overtapped.

"Experience seems to show that young and vigorous trees [presumably wide-planted] can be tapped at a rate which exhausts the available bark in four years, at the same time making good growth and giving a steadily increasing yield. . . . The results here obtained may be taken, however, as a warning that there are strict limits to the recuperative powers even of Hevea. In fact the Heneratgoda experiments may be said to endorse the view that, *even in the case of the most vigorous trees*, the period allowed for the first renewal should not be reduced below four years."

A bad argument, but a sound conclusion.

While thoroughly in agreement with this dictum, and without wishing to appear to be supercritical, this is just what the Heneratgoda experiments *do not show* to the writer. Considering the condition of these old trees, it seems unfair to style them "the most vigorous trees" and then argue from them. A rubber tree is vigorous chiefly from the standpoint of its healthy ability to yield latex and increase its growth. A grove of twenty-year-old trees planted 12 feet by 12 feet may be vigorous from the timber standpoint, but the yields per tree per annum show them to have been the reverse of vigorous from a planter's point of view. It may be interesting to Malayan planters to read the figures of actual measurements of these trees given in the bulletin, bearing in mind the fact that the writer has measured twenty-year-old trees in this country (not close planted) ranging from 70 inches up to 103 inches in girth at a height of 3 feet from the ground.

What is a vigorous rubber-tree?

Measurements of experimental trees.

AVERAGE CIRCUMFERENCE IN INCHES.

Row.	June, 1908.	June, 1912.	Average annual increase for 4 years.
I. . . .	36·2 ins.	39·5 ins.	0·82 ins.
II. . . .	34·9 „	39·1 „	1·05 „
III. . .	31·3 „	37·2 „	1·48 „
IV. . .	33·6 „	38·6 „	1·25 „
V. . .	33·9 „	39·5 „	1·48 „
VI. . .	40·2 „	44·1 „	0·98 „
VII. . .	39·6 „	42·2 „	0·65 „

Only equal to six-year-old Malayan trees.

It will be seen that these close-planted twenty-five-year-old trees are even now only about equal in growth to our Malayan trees of five to seven years when planted, say, 20 feet by 20 feet. Under these circumstances it will be obvious that the results obtained in the Ceylon experiments must not be applied too seriously in considering the whole question as it has any bearing, direct or otherwise, upon planting problems in Malaya.

To sum up the criticism of the Ceylon experiments, it might be said that :—

1. The experiments and the results are of very little value from a practical point of view.
2. The experimental trees were too closely planted and ill grown.
3. The system of tapping and the method of tapping were so severe, especially for such closely planted and ill-favoured trees, that the trees tapped at more frequent intervals were bound to suffer heavily and had no chance to recuperate. Hence the trees tapped more conservatively are bound to show up better in the long run. What might have happened had a rational method and system of tapping been adopted, would probably be rather different.
4. If we judge by the average annual yield per tree (not per acre) in any section, we find the trees to be not normal from a planting point of view, the yields being so miserably small.

To argue from these experimental results to healthy plantation trees planted 20 feet by 20 feet (or even wider) is quite as unfair as for one to judge the behaviour of normal healthy persons from a prolonged study of decrepit hospital patients.

5. Some of the deductions made by the experimenters are not truly logical in the light of what they knew in the course of the experiments.

If these points may seem to be rather sweeping to some readers, it should be remembered that the results of the experiments have been so widely circulated, and have met with such a meed of approbation that strong criticism has been courted.

A PRICKING METHOD.

Methods of tapping trees by pricking methods have never been popular in this country, and have largely fallen into disfavour in Ceylon. It has been clearly demonstrated that the old pricking methods employed in Ceylon resulted in much harm to the trees. A new system, the Northway, has acquired a little vogue recently. The pricking instrument, described roughly, can be compared to a broad wood-chisel from which equal rectangular pieces have been cut out. Thus there are four parallel prongs each forming a miniature chisel about one-eighth of an inch in width. In using this pricker (the guard of which can be adjusted according to the thickness of bark) the outer bark of the tree is first scraped clean. The pricker is then used to make an oblique series of incisions one beneath another, and the latex is guided into a main perpendicular direction to the cup. It is claimed by the inventor that the yield of latex obtained in this way is equal to, if not superior to, that obtained by excision methods. Not only so, but the incisions heal over rapidly, and no trace of them can be seen in the bark after a comparatively short interval. The writer has not had an opportunity of seeing any comparative tapping results, so that he is unable to judge the ordinary value of the system. Under one condition, however, there may be a possible use for this pricker in Malaya. It must have been apparent to planters that the number of burrs on older trees is on the increase. This problem of nodular formations has received the attention of many investigators, but no satisfactory physiological explanation for the formation of nodules has been yet adduced. Some few theorists incline to the opinion that they result from bad tapping. As nodules are to be found on trees which have not yet been tapped, such a general statement is controverted. In the opinion of the writer there is considerable ground for belief, on the contrary, that the nodules are responsible in some cases for the apparent bad tapping. Whatever the exact case may be, it is very obvious that in the case of some veteran trees ordinary excision methods of tapping only

NODULES OR BURRS ON TREES.

aggravate the abnormality, and that in the near future these trees will either have to be neglected as means for obtaining latex, or other methods of tapping will have to be introduced to meet the special conditions. A few estates have, in some fields, quite a large percentage of these old trees afflicted with nodular growths, and it becomes increasingly difficult to tap them. Under such circumstances it is possible that the new Northway pricker may be of some service. By its use one will be able to obtain the latex which at present is almost inaccessible by ordinary means. It would be difficult to imagine, however, that any fair percentage of first latex would be obtained; and it is probable that the majority of the rubber would take the form of scrap. Estates having old areas in which the trees suffer badly from "burrs" have a very difficult problem to face. Systematic work is done on some estates in removing the young growths as soon as they appear, and it would seem that this method is fairly successful in keeping down the number of cases. The rate at which the nodules grow or amalgamate on some trees is extraordinary, especially in a perpendicular direction, and these lengthy growths are impossible to eradicate without cutting into the wood of the tree. Even then the chances are that the whole has not been cut out and there may be a recurrence of the trouble. In the case of closely planted areas, it has been suggested that it would be better to make a clearance of the badly affected trees and to re-plant. There is certainly much reason in the suggestion, but it remains to be seen whether it is sound on questions of practical utility.

CHAPTER III

TAPPING AND COLLECTING

DURING the last two or three years the number of cases in which trees were being "top-tapped" has diminished considerably. It must not be forgotten that top-tapping (*i.e.* tapping above a height of about six feet from the ground) was only a necessity on most estates because of the too rapid removal of the lower bark. It was commonly asserted to be due to the slow renewal of the lower bark, but there are very good grounds for believing that this so-called slow bark renewal was merely the outcome of a system or systems of tapping which removed the bark too rapidly; and hence sufficient time for good bark renewal could not be allowed without having recourse to top-tapping. It follows, therefore, that as the general planning of tapping systems continues to improve, longer periods for bark renewal will be allowed, and the necessity for top-tapping will cease to exist except in very exceptional cases. It has already been pointed out in the first chapter that periods of four years for bark renewal are now the general rule. Cases are likely to occur in closely planted old areas in which even four years will be found to be inadequate for full renewal. To return to the new bark would be a great mistake, as each repetition of tapping over insufficiently renewed bark shows a diminished or stationary output, and the chances of injury to the trees are multiplied. In such a situation the planter has a choice of :— Top-tapping.

1. Re-planning his tapping system so as to allow for longer bark-renewal.
2. Thinning the field and cultivating it.
3. As a temporary measure to allow of a longer period of bark renewal, top-tapping for a year or so.

Under such circumstances temporary top-tapping could be advantageously employed, but only on the understanding that other measures are to be adopted as soon as possible. It

need hardly be pointed out that no planter would, if he could avoid it, tap above a height of six feet, for some very solid reasons:—

1. Top-tapping is much more expensive owing to the fact that some form of ladder has to be carried by the coolie, and hence the amount of work he can do is diminished.
2. Top-tapping is more expensive than lower tapping, because the yield of dry rubber obtained is less in proportion to the number of cuts.
3. For top-tapping some special form of cup-hanger has to be provided, and the breakage in cups is heavier than for bottom tapping.
4. The work cannot be supervised so well, and wounds are more likely to pass unchecked.

The general public might have an erroneous idea of top-tapping, and imagine that the tapping area extended to a great height. It is very rare that the tapped area extends above a height of three feet from the usual lower limit of six feet from the ground. It is well known that the nearer an incision is made to the base of the tree the richer is the latex obtained (*i.e.* the greater is the dry rubber content of the latex), and the farther removed from the base the poorer the latex (*i.e.* the less actual rubber it contains). It might be said that the nearer the base of the tree, the greater the yield in proportion to the length of cut; but confusion between yield of latex and actual yield of rubber must not arise. It might be possible for a cut at a height of six feet from the ground to yield a quantity of latex equal to a cut of same length at a height of two feet, but the yield of dry rubber per equal volume of latex would be greater in the latter than in the former case.

Again, taking two extreme cases, that there is a difference in actual quality between the rubber obtained from the latex of a cut near the base of a tree and that obtained from the latex in the leaves, is certain. We have some grounds for inferring that this inferiority in the quality of rubber obtained from the crown of the tree extends, to a lesser degree, to the rubber obtained from the latex exuded by cuts high up the trunk of the tree. But that there should be any appreciable difference in the quality of rubber obtained by tapping at a height of nine feet in comparison with that obtained at a height of five feet is rather doubtful. No vulcanisation tests have shown this difference to

exist. It may be assumed, then, that the objection to ordinary top-tapping on account of any appreciable inferiority in the quality of the rubber cannot be sustained.

DARK SCRAP RUBBER.

As a matter of practical observation, however, it has been noted as peculiar that the latex obtained from top tapping shows a greater tendency to form black scrap than does ordinary latex. In other words, it appears to oxidise more rapidly. Until a comparatively recent date it was supposed by planters that this rapid oxidation of the latex was an indication that the tree was suffering from attacks by white ants. In the course of thinning out many acres of trees, the writer was able to show that there was no justification for this belief. The oxidation is primarily due to an enzyme and also to the presence of chemical substances of a phenolic character. In the course of laboratory experiments with normal latex, it was found possible to reproduce this darkening due to oxidation by the addition of very small quantities of various phenols used in general chemical processes, and the rapidity with which the darkening was effected depended upon the quantity of the phenol added. If this rapidly oxidising latex obtained from top-tapping be mixed with normal latex, it would seem that the whole bulk of the latex is affected by this tendency to rapid oxidation; and it is advised, therefore, that in such cases the latex from the particular trees be not collected, but be allowed to coagulate in the cup. It is observed that this condition under which any tree may yield rapidly oxidising latex is not a permanent one. It is merely a phase in the tree's existence, and in the course of a period which varies widely from a month to many months the latex again becomes normal.

Another very fine point adduced against top-tapping is that by it the renewal of the portion of bark perpendicularly below the tapping area is retarded to some degree. There would appear to be some evidence in favour of this view, but probably retardation would be only slight.

Sufficient has been written to show that not only is top-tapping economically inferior to bottom-tapping on the score of expenditure and return, but also that there are certain disabilities connected with the physiology of the tree. All that remains is to repeat that top-tapping must be avoided by planning tapping systems which will allow an ample period for bark renewal, say four years in young and medium-aged trees, and more than four years in older or more closely planted areas.

Where the planting is wide it will be found, probably, that four years will be sufficient in any but exceptional circumstances.

TAPPING-KNIVES. This is a subject upon which there is much divergence of opinion. This must necessarily be so because no facts can be readily produced on behalf of the claims of any particular knife. Moreover, the personal factor is so large as to fairly dominate the question. It is an understood thing that planters are always on the look-out for the ideal knife. The chances are remote, however, of obtaining this wonderful knife which will go deep enough into barks of varying thickness to obtain the maximum of latex, and yet will not allow the coolie to wound the cambium. The search for the ideal still continues, and much brain labour has been expended in various weird and wonderful machines and instruments which only fulfil requirements theoretically.

In Malaya only three types of knives are in general use. They are :—

1. The gouge—straight or bent.
2. The ordinary farrier's knife.
3. Modifications of the farrier's knife, such as the "Jebong" knife.

On a few estates only do we find other knives used, and they are generally local patents. Argument on the respective merits of the knives instanced above is very popular and provokes eternal discussions. It is claimed for the bent gouge that it is much superior to the straight gouge because the leverage being downwards on the handle the tendency of the cutting edge is to cut out of the bark, whereas with a straight gouge it is advanced that the tendency is to push downwards into the bark. In a similar manner it is stated that the Jebong and other modifications are superior to the farrier's knife. These points are generally accepted without much argument; but when comparisons are made between the gouge and the farrier's knife (with its modifications), the opinions of planters are so varied and so conflicting that the layman is absolutely nonplussed. Each manager is willing to give his opinion as based upon actual experience of the two types of knives, and any two such opinions are often wholly contradictory.

As already pointed out, there can be no doubt that the likes and dislikes of coolies have a considerable influence in determining the measure of success obtained by any knife. Should coolies have been accustomed to the use of one knife they become quite

expert, and if a change is made the prejudice created in the minds of the coolies is considerable and militates against the operation of the new knife. Such prejudice can only be overcome by time, but in the interval not a little damage may have been done in the shape of tapping wounds. It does not become the writer to advise practical planters on the choice of a tapping instrument, but in his opinion the best work is obtained by choosing a simple non-adjustable knife and retaining it.

THE CHOICE OF LATEX CUPS.

Even as recently as two years ago much could have been written on the lack of thought expended on the collecting cups, and the false economy then practised. It is rather uncommon, however, at the present time to find estates lacking in the necessary equipment of cups that can be easily cleaned. The half coconut-shell has disappeared, and none can regret its passing. There could be no question that they were unclean and could not be scrapped properly. When they were regarded as hopelessly dirty with accumulations of old scrap rubber they were either thrown away or burned. On one estate, by taking a thousand of these abominations and carefully scrapping them, the writer was able to demonstrate that the loss per annum calculated over the whole estate did not fall short of £600, at the prevailing price of rubber. The cost of equipping the estate with glass cups was calculated to be about £300, so that by gain of scrap rubber the new cups would pay for themselves within six months.

Terne-plate cups gradually ousted coconut shells, and they had the merit of being comparatively cheap. The interior coating of tin did not last long, especially if the cups were properly scrapped and cleaned. The iron being exposed, with a minutely roughened surface, each little projection served as a point around which latex coagulated. The cups soon began to be regarded as impossible to scrap or keep clean, and eventually they were generally burned out, rubber being lost in the process. On some estates successful efforts are made to keep these cups clean, by making the coolies bring them into the store each day. On a very large scale this is understood to be impracticable. These terne-plate cups are still in common use and, speaking generally, are usually in a dirty condition.

The writer is often asked to decide between the choice of glass cups and porcelain-finished white-ware cups. As a rule it is easy to see that white-ware cups must be more economical in the long run. The only advantage which glass cups give over

white-ware cups is that it is so much easier to see from a glance, when the cups are on the supports, whether they have been scrapped or not. Otherwise in the matter of ease of scrapping there is apparently no difference between the two types. In spite of the fact that white-ware cups are a little more expensive than glass cups, in their favour we find that:—

1. The percentage of breakages in transport is small in comparison with the breakages in glass cups.
2. The percentage of broken cups in the field is smaller than is the case with glass cups, *i.e.* the "life" of the cup is longer and it stands rough treatment better.

Glass cups are generally made in one or two patterns—the flat-bottomed cup or the one having a conical base. The latter is supposed to give an advantage in placing the cup in a convenient hole. In practice the peculiar shape of the base is found to be a nuisance. Coolies attempt to stand the cup on the apex and keep it upright by means of sticks or stones. The slightest touch is sufficient to upset the balance, and latex is lost. In addition to this drawback, it is found that the difference in the thickness of the walls makes for a large percentage of breakages in the field. There are on the market, and in fairly wide use, cups of Chinese and Japanese manufacture, consisting of brown earthenware with an interior glaze finish. These are cheap in comparison with glass and white-ware cups; but it is a pity the glaze does not extend over the whole of the cup. The outside surface has a tendency to collect rubber and dirt. If the cups are properly cleaned this disability vanishes. On the whole, therefore, the choice in cups lies between flat-bottomed glass cups and similarly shaped glazed white-ware cups. Of the two it has been shown that the opinion of the writer distinctly favours the latter.

CLEANING CUPS. The question of cup-cleaning would appear to be a very simple one; but in practice it is quite a source of worry to managers, especially on estates having to work a mixed labour force. Tamil coolies can be made to clean their cups in the day's task, but Chinese coolies, more often than not, either will not or they require extra pay for the work. It can be readily seen that, speaking generally, estates working Chinese labour usually have dirty cups. Occasionally it becomes an absolute necessity that the cups be scrapped, and it is then found that the task is impossible to complete thoroughly.

On some estates it is the custom to replace the cup after

having poured out the latex. A little is bound to remain, and the cups are dry-scrapped the following day, or at least that is what is supposed to happen. As it is quite impossible for the European staff to inspect anything more than a fraction of the number of cups daily, it follows that the careless coolie often has an accumulation of three or four days thin layers of scrap in his cups. It then becomes increasingly difficult to take this scrap out, especially if the cup is so situated as to be in the direct rays of the sun for a few hours each day. Under such circumstances the rubber becomes slightly tacky; so that even when recovered it is inferior in quality. Providing that the cups are cleaned after every tapping, there are no objections to this method, with the exception that a better grade of rubber is obtained by washing out the remaining latex after collection.

The other mode of cup-cleaning is alluded to in the previous sentence. The coolie collecting latex carries two buckets, one for receiving latex and the other containing water. After the latex has been poured out, the cup is rinsed in the water and replaced in an inverted position. By the time a coolie has emptied and washed a hundred cups the water has the consistency of dilute latex, and the wet cup when replaced eventually becomes covered with a thin film of rubber. If the latex is always collected in the same direction it will be plain that while the cups at the beginning of the rows are fairly clean the ones at the end of the direction will become more and more covered with rubber. It is very difficult, from an outsider's point of view, to see why this cannot be rectified; but one recognizes that under existing conditions of controlling labour one cannot force coolies to observe rules, and moreover one has no redress against them.

Apart from the question of the effects of cleanliness, it must be recognised that the annual loss of rubber due to the irregular and improper cleaning of cups is quite considerable; and for these reasons it is incumbent upon all managers to see that cups are cleaned as far as it lies in their power to do so.

Water in cups.

It has always been laid down by your chemists that no necessity existed for the ordinary practice of putting water into the collecting cups. It must be confessed, now that the evils arising from the use of excessive amounts of water of doubtful quality have been abated, that there are exceptions to be made. It was not judged wise to promulgate these exceptions at an earlier stage, because it was felt that otherwise no general

improvement would have been made. These exceptions will be discussed in Chapter XV. (on the "Defects of Sheet Rubber"), and the reader is referred to that portion of the book.

It is still maintained, however, that in general, given clean cups and efficient labour, there is no necessity for water to be put into cups on an estate preparing crêpe rubber. On quite a large number of estates it is now the common practice to put down dry cups. The tapping coolies are allowed to run a few drops of water down the perpendicular channel with the idea of easing the flow of latex. Sometimes this is effected by means of a leaf stalk dipped into water, on other estates the coolies make with leaves small conical bags tied at the apex with thread. The water trickles out in quick drops, and the apex of the bag is run up or down the main channel. Many planters maintain that there can be no middle course of action with regard to this question of water in the cups. Various are the ingenious devices for teaching the coolie to put only a little water. Some estates stipulate the quantity of water which can be contained in a rubber-seed shell. Others prescribe just sufficient water to cover the bottom of the cup. Naturally much must be left to the intelligence of the coolie, and it is not surprising to see cups containing about an ounce of water into which will drip perhaps one quarter of an ounce of latex. From repeated observation it has been found that the proportion of water to latex in the case of young trees often is as high as six or eight to one. In a later chapter it will be shown that this over-dilution of latex results in an inferior rubber. On some few estates the proportion of water to rubber in some of the cups was even higher than the figures given above, so that the latex as a whole was very dilute. In one instance sheet rubber was being made for the first time, and these sheets when dry did not weigh more than 4 or 5 ozs. When coagulated the rubber was of an open meshwork texture, and after the sheets were rolled and hung to dry they stretched over the support. Finally they came out of the smoke house resembling in shape double-ended scarfs. On the calculation that a gallon of latex containing 30 per cent. of rubber would yield a sheet weighing, when dry, about 3 lbs., it can be seen that the particular latex alluded to only contained about 3 per cent. of rubber. Assuming that the latex as it came from the trees (about 7 years old) contained only 24 per cent. rubber, it is plain that the proportion of latex to added water over the whole field in

this case could not have been greater than 1:7. With latex of this dilution it is, of course, impossible to make sheet rubber, and even crêpe rubber suffers in quality. The question of abuse of water in the cups is therefore an important one, and it is noted with pleasure that steps are taken on most estates to keep the quantity of water at a minimum.

Little can be said on this point, as it is most unusual to find dirty collecting pails at present. Still, one or two instances have been noted even recently in which better supervision would have improved matters. It is the practice on some estates to use, as vessels for collecting latex, old kerosene tins. Doubtless they are cheap, but it is obvious that any vessel in which there are angles must be very difficult to keep free from coagulated rubber. All vessels intended for the reception of latex should have a smooth and curved interior, so that the process of cleansing is easy. Preferably the interior and exterior surfaces of the vessels should be glazed, but it is often found that the enamel on buckets in use has an annoying way of becoming chipped easily. The iron being thus exposed, the difficulty of cleaning the bucket is intensified. Something stouter in material is badly required in the shape of enamelled ware, and until that arrives the heavy galvanised and brass-bound milk-pails used on some estates are as good as anything at present in vogue, providing they are kept scrupulously clean. PAILS.

CHAPTER IV

TRANSPORT OF LATEX

FIELD STRAINING AND PERCENTAGE OF FIRST LATEX.

ONE of the problems confronting any manager is the question of the percentage of first grade rubber calculated upon the whole output. Inquiries are constantly being received for advice as to what the various percentages of each grade of rubber should be. This is a question to which no definite list of figures can apply. There are so many little factors influencing the result. Some estates are not particularly careful in collecting tree-scrap. Hence quite a quantity of tree-scrap finds its way into the crêpe made from bark-shavings. On the other hand, bark-shavings are not collected systematically on some estates, and the total output is thereby diminished. In consequence the first-grade rubber shows a higher percentage than it would otherwise. Again, if the earth-rubber is not regularly collected the percentages of the best grades are higher than they should be. In comparing the percentages of each grade of rubber from any two estates, therefore, one should have all the information possible as to the various working details of the estates. Without wishing to lay down any definite proportions which can be applied to all estates it might be said that, taking averages over a large number of estates, the percentages to be aimed at are :—

First-grade latex	70 per cent. to 75 per cent.
Other grades	25 " " 30 "

For these figures one premises that all lower grades are collected and accounted for carefully and regularly. The distribution of the lower grades will depend upon the field practices of the particular estate; but the following list might be given for an estate keeping all lower grades distinctly separate :—

First-grade latex	70 per cent.
Cup-washings / Coagulated lump, etc.	$12\frac{1}{2}$,,
Tree-scrap	$7\frac{1}{2}$,,
Bark shavings	5 ,,
Earth rubber	5 ,,
	100 per cent.

Emphasis is again laid on the statement that these figures must not be accepted as a standard. Nevertheless, they may prove of some service to managers in giving an idea of what the general line of percentages may be. There are special circumstances, such as distance of transport and the nature of the land, which at present would render the attainment of 70 per cent. first-grade rubber impossible on some estates. Still the fact remains that if the percentage is low through distance of transport, etc., some method will have to be discovered by means of which the difficulty may be overcome. On a few estates the percentage of first-grade rubber obtained sometimes reaches 75, but these results are rather out of the ordinary. An estate which collects all lower grades properly is doing very well if the percentage of first-grade rubber is 70 or thereabout.

Early collection.

This brings us to the question of means whereby the percentage of first-grade rubber may be increased. First and foremost, probably, is the question of water in the cups. Many managers find from experience that if the cups have no water put in them the amount of coagulation in the cup is increased. Although this does not agree in general with the experience of the writer and others, one can imagine it to be the case where latex is allowed to stand for a considerable time. It has been observed on a very few estates only that the interval between tapping and collecting is unduly prolonged. Managers do not need to be told that the collection must be as early as possible.

Field straining.

From fields near the factory it is usual for each coolie to carry in his collection of latex, which arrives fairly free from coagulated lumps. Transport from distant fields, however, is a much more complex matter. Usually the coolies bring their pails of latex to a centre, where it is poured into a large galvanised circular tank supported on wheels and drawn by cattle. As a rule, after having picked out stray leaves and other objects, the coolie pours the latex direct into the tank. A certain amount of coagulated rubber goes in with the latex. It must have been commonly observed

that the amount of coagulated lump in the tanks on arrival at the store is much greater than the quantity poured in with the latex. One can easily understand why this should be so. Estate roads generally are not quite up to the standard of the very poorest macadam road, and the tank is continually jolted. This jolting motion exerts a kind of churning action upon the latex, and the coagulated lump "grows" in proportion. This is a matter of common observation.

It is not so common, however, to find that the small coagulated lumps from the buckets are removed by straining in the field. On one estate this was recommended and carried out with success. Large coarse sieves were made to fit inside the top of the tank. It was not found necessary to use such a fine mesh for the sieve as is used in the factory for the final straining. All that is required of the coarse sieve is that it shall remove coagulated lumps and other objects. If the sieve used in the factory is made of 30-mesh gauze the one for field use may be 15-mesh. On the estate to which reference has been made it was found after one month's trial that the percentage of first-grade rubber had been increased by 4 per cent. or 5 per cent. This was extremely gratifying and showed the necessity for attention to details. Further reference to the question of cart transport will be made in this chapter.

USE OF FORMALIN.

It is not easy to understand why the use of formalin as a means of retarding coagulation is not more popular. The question of expense has sometimes been advanced, but when the cost comes to be reckoned there is seen to be nothing in this argument, especially as formalin would only be required for treating latex which has to come a considerable distance. One manager who has used the chemical with much success was good enough to supply me with figures of cost. An expenditure of about $12 per month was necessary. Against this we have to reckon that the output of first-grade rubber per month was in the region of 20,000 lbs. This works out at about $\frac{1}{17}$th of a cent. per lb. of dry rubber. Assuming that the percentage of first-grade rubber was increased by this means to the extent of 5 per cent. (1000 lbs. approximately), and that the difference in price between first-grade rubber and second-grade rubber was ½*d.*, there would be a gain to the estate of £2 1*s.* 8*d.* as against an expenditure of £1 8*s.* Thus the formalin would more than pay for itself, and the percentage of first-grade rubber would show an improvement.

On another estate where latex had to be carted some three miles, the following proportions of formalin were used :—

1. A 20-per-cent. solution of formalin was made.
2. One latex cup of this solution was added to a cart tank containing 80 gallons of latex.

On arrival at the factory there was found to be only very little coagulated lump, whereas if no formalin were added it was often found that the cart arrived containing, not latex, but one mass of coagulated rubber. In these circumstances it was not a matter of an increase of 5 per cent. but a saving of the whole volume. It is also to be noted that no additional acid was found necessary for complete coagulation, although with larger quantities of formalin this is generally the case.

In yet other instances formalin has been used in cases where coolies have to carry their pails of latex some considerable distance. The solution of formalin is usually placed in the collecting pail. For this purpose a solution is made of 2 ozs. formalin to one gallon of water. Of this solution sufficient is put into each bucket to cover it to a depth of from 1 inch to $1\frac{1}{2}$ inches. It is found necessary sometimes to use a little more than the minimum quantity of acid.

SODIUM SULPHITE.

One of the drawbacks in the use of formalin is its loss by evaporation. Something in the form of an anti-coagulant is required which will not lose strength even if the solution becomes less in volume by evaporation. There are several such substances known to the writer, and experiments have been made with them in the laboratory. As a result of these experiments he has come to the conclusion that the most satisfactory substances yet dealt with is ordinary sodium sulphite, the "sulphite" of the photographer. It must not be confounded with the bisulphite now so largely in use.

Sodium sulphite has the great advantage over formalin of being solid, and yet easily soluble. In fact, its ease of solubility is almost a disadvantage and necessitates careful sealing of the container. This disadvantage could be overcome easily by making up a standard solution from the whole contents of one or more vessels at a time. This solution could be kept sufficiently long for practical purposes without deterioration.

Work was done with this chemical more than twelve months ago, but there has been not a small difficulty in obtaining managers sufficiently interested to try experiments on their estates. In the original estate-test the latex had to be carried

in pails by coolies over three miles of rough track. Two buckets of latex were taken, and to one was added a small quantity of sodium sulphite. In order to make the test more severe, both buckets were allowed to stand in the sun for two hours after collection before being carried. On arrival at the factory it was found that in the bucket of latex treated with sodium sulphite there were 3 or 4 ozs. of coagulated lump, whereas practically the whole of the latex in the other had coagulated.

This substance has also been tried on a larger scale for putting into the large 80-gallon cart tanks. There was a marked improvement soon visible, but later and more full reports are expected shortly. Where the cart has to travel some miles, the following proportions for use were tried successfully :—

1. 1 lb. of sodium sulphite dissolved in 1 gallon of water.
2. Of this solution use 1 fluid oz. to every gallon of latex.

Other experiments are now being carried out on estates in order to find the minimum proportions of a solution to be put into the latex cups, thus preventing coagulation at the source.

Naturally one requires to know the cost of this chemical. Inquiries have been made, and it is found that the lowest list price for commercial sulphite is about 18*s*. per cwt. The chemical would have to be packed in air-tight drums, and this would mean, with the addition of freight, that the lowest price here would be in the region $12 per cwt. It is possible, however, as happened in the case of sodium bisulphite, that the demand will bring into existence other commercial quotations, and that the price will be below $11 per cwt. This would work out at about 9 cents per lb., in contrast to which the local price per 1-lb. bottle is 50 cents.

As to the effect of sodium sulphite upon the final rubber, managers can be assured that there is none with the quantities recommended. Care should be taken, however, that an excess of the chemical is not used, otherwise coagulation may be unduly retarded, and it will be found necessary to use a large excess of acid to effect complete coagulation.

SODIUM BISULPHITE.

Sodium bisulphite is not recommended as an anti-coagulant, though it is observed to act as one on occasions. This generally happens when the bisulphite is allowed to stand for any length of time in contact with latex. As a matter of fact, sodium bisulphite has an acid character, and it is difficult at first to see how it can act as an anti-coagulant.

The action may be ascribed to the slow, gradual change of

the bisulphite in solution to the ordinary sulphite mentioned in foregoing paragraphs. It has been tried on one or two estates, where a solution has been used in the latex cups. It is claimed that not only is the colour of the rubber better, but that the percentage of coagulation in cups has fallen considerably.

There can be no doubt that the transport of latex from distant fields over estate roads is responsible chiefly for a loss of first-grade rubber. It is one of the most common sights on estates to see large latex carts arrive at the factory containing great clots of coagulated rubber. Although we know that intrinsically this rubber is at least equal to the rubber obtained from coagulation of latex with acid, we have to recognise that, owing to the rapid oxidation which sets in, the colour of the final rubber is inferior to ordinary first-grade rubber, and the price obtained is lower. Of course, in combination with the jolting motion, the length of time taken by cattle on the journey is a factor which makes for natural coagulation, and the more quickly latex reaches the factory the better the percentage of first-grade rubber obtained. For this reason any reasonable means of hastening the transport of latex is worthy of serious consideration. LATEX CARTS.

Hence it is noted with pleasure that estates are considering the advisability of installing narrow-gauge railways where possible. It is granted that on a large number of estates these tramways would be impossible to work by coolie labour; but there must be many through which it is possible to lay down a railway having very easy gradients. If the trams are fitted with wheels having ball-bearings, the ease with which the trucks are moved is surprising. The writer has seen, once a start has been made, a coolie push an 80-gallon tank of latex on a truck a distance of two miles in a fraction of the time usually taken by cattle. It would seem feasible on some estates to run one or two main lines of rails to centres along which coolies could bring latex. The saving in cattle labour could be no small consideration; but, as already pointed out, the saving in time of transport is particularly to be insisted upon. It may read as rather extreme to some managers, but to the writer it would appear even necessary to consider whether, on undulating estates, it would not be wise to suggest that some form of locomotive power be used in conjunction with the ordinary trucks. TRAMWAYS.

In Ceylon and other hilly countries transport by overhead

OVERHEAD ROPE-WAYS.

rope-ways is common, and what is feasible in those countries should not be impossible to execute in this country. The matter has the attention of some few estates, and it is possible that in the near future the schemes will materialise. The writer is assured by expert advice that there are no great engineering difficulties, and this being so, there seems to be no insuperable reasons why more estates should not study the question of improved means of transport. It is apparent that the problem of maintaining an efficient labour force is becoming increasingly acute, and we should expect that any means whereby saving of manual labour can be effected would receive the most careful attention of those interested. It is probable that the scarcity of labour is not thoroughly appreciated by Home authorities, and the writer would commend these observations to the close consideration of directors.

CHAPTER V

GENERAL FIELD OPERATIONS

Coagulating centres.

Following naturally upon the question of transport we arrive at a discussion of the necessity or otherwise for coagulating centres in the field. At first sight this would appear to be a subject of interest only to estates on which crêpe rubber alone is prepared, but the remarks apply equally well to estates preparing rubber in sheet form. It has been pointed out in the previous chapter that great attention must be given to the acquisition of the highest possible percentage of first-grade rubber. It will have been apparent from preceding arguments that the greater the amount of transport involved the lower the percentage of first-grade rubber will be. In the absence, therefore, of thoroughly efficient means of transport it will be seen readily that the existence of field coagulating centres is well justified. These coagulating sheds (for the preparation of crêpe rubber) usually consist of an attap roof supported by rough posts. Anything more elaborate is not required apparently. In each of these sheds are a number of large glazed earthenware jars into which the latex is strained. As a rule supplies of acid and sodium bisulphite are sent out from the factory made up into solutions of the requisite strength. A skilled coolie is put in charge of each centre and he is visited by the European supervisors. On some estates there are as many as twelve or fifteen of these sheds, and it must be plain that transport of latex is reduced to a minimum. When the rubber is completely coagulated it is carted to the central factory to be machined into crêpe form. The period necessary for complete coagulation is usually under two hours and rarely exceeds three hours.

Where sheet rubber has to be made the coagulating centre needs to be rather more of a structure than in the case of coagulating for crêpe preparation. It would be necessary to provide pans in addition to the large jars for mixing. Moreover,

the shed should be capable of being locked up, as coagulating pans are articles which can be easily removed. As it is the general custom to allow sheet rubber to coagulate overnight, this would necessitate a more highly complex organisation of forces. Under such conditions, therefore, one could only recommend a limited number of coagulating centres each in charge of a watchman, unless the sheet rubber was removed to the central factory each day as is done in the case of crêpe making. There would be no serious objection, on scientific grounds, to the latter course, as the results of vulcanisation tests go to show that no appreciable advantage is gained by leaving sheet rubber overnight as compared with sheets removed for rolling after four hours. This point is dealt with in Chapter VIII.

It is to be noted that in the event of coagulating centres being used the rubber shows a tendency to oxidise during transport, but that this disability is entirely overcome by the use of sodium bisulphite, and the final colour of the rubber does not suffer in the slightest degree.

TRANSPORT OF COAGULUM.

Finally, it is recommended that, on hilly estates where the problem of transport of latex is a hard one to face, coagulating centres should be erected, as the transport of coagulum (coagulated rubber) is a much simpler matter than is the case with latex. Unfortunately the exact kind of vehicle has not yet been found. It is not found feasible to use the latex cart-tanks as their progress is slow, and their capacity is limited. The ordinary estate cart can be divided up so as to contain the coagulum from two or three coagulating centres, and hence it would appear to be the best for the purpose. If the estate were provided with an overhead ropeway the transport of coagulum would be very simple. One of the drawbacks experienced in using wooden carts is that in the course of a comparatively short time the timber appears to become affected by the acid liquid, and splinters are found adhering to the rubber. It has been proposed to line the cart with galvanised sheeting. No doubt this would last for some time, but eventually it would be worse than anything. Once the zinc surface deposit became pitted iron-stains would appear on the rubber. A cart has been seen, the interior of which was lined with glazed tiles set in cement. If this should last well it should prove to be the ideal way of transporting coagulum; but it can hardly be expected that the tiles will remain intact for very long even if the cart

travels over good roads. It has been suggested that the lining of the cart should take the form of enamelled sheeting, made to the shape of the cart and built up to fit the cart. Large objects are now made extensively in enamelled sheeting so that there should be no great difficulty in obtaining the necessary article; but here, again, one drawback is obvious. As soon as the enamel begins to "chip" the trouble with iron-rust will become evident. What is required is some form of glazed-surface tank which will not increase the weight of the cart unduly, and will not "chip" easily.

COLLECTION OF TREE-SCRAP.

There should be no necessity to mention this elementary detail of estate working, but it is rather surprising to see how indifferently the collection of tree-scrap is regarded on some estates. In many instances tree-scrap has been noticed upon the trees which were then being tapped. The tapper was not expected to scrap the tree too carefully, yet collection of tree-scrap was included in his work. The result was that the scrapping was done in a very hurried manner, and a large proportion of the scrap remained on the bark shavings, some of which was picked up and some was not. The fact that tree-scrap went into the factory with bark-shavings would not be out of place if the two usual grades, tree-scrap crêpe and bark-shavings crêpe, were prepared as one grade; but where they are supposed to be distinct the returns would be misleading. Should it be considered advisable to prepare the two grades as one, the only serious objection would appear to lie in the fact that a grade of rubber would be prepared slightly superior to bark-shavings crêpe and yet containing traces of bark. Where a Universal Washer is in use this objection would probably vanish.

OXIDATION OF TREE-SCRAP.

This topic has already received attention in the first section of Chapter III., and little remains to be added. It is probable that not enough care is paid generally to the so-called lower grades of rubber, and it is not uncommon to see tree-scrap piled in heaps upon the floor of factories. In this position it suffers quite an amount of contamination from dirt, and oxidation proceeds fairly rapidly. Where the scrap-rubber has to remain for any length of time before it can be worked, tanks should be provided in which the rubber can be submerged in water. In this way any adhering particles of dirt and bark are softened and surface oxidation is minimised.

COLLECTION OF BARK.

In the matter of collecting bark-shavings much depends upon the organisation and nature of the labour force. Probably

on the majority of estates bark-shavings are collected systematically, but on quite a number considerable laxity in this respect has been noted. This may arise from lack of adequate supervision or from the peculiar systems of working which seem to pertain to Chinese labour. Granted that the trees are well scrapped, and that the percentage of rubber obtained from shavings under such circumstances would be extremely small (say 2 per cent. by weight on the total output), it does not need much calculation to see that annually the loss of rubber to the estate must be considerable. It would also seem to follow that, if the adult labour declines to pick up bark-shavings carefully, it might pay to employ children for the purpose. Or, as is done in some places, the adult labour might find it advantageous to collect bark-shavings at low rates per lb.

It is a well-known fact that if bark-shavings be allowed to accumulate in a heap for any but a short period, a fermentative and heating action is set up. The heat developed in these piles of shavings is so considerable, that it is impossible to keep the hand in a heap for more than a second or two. Should this be allowed to persist, as would happen in the case of a break-down of engine or machines, it usually results in the final crêpe rubber becoming tacky when approaching dryness.

To avoid this heating effect it is necessary to have spare jars or proper tanks in which the shavings may be soaked in water. In this condition bark-shavings may be kept for many days.

For the same reason (*i.e.* the heating effect and consequent tackiness) the custom followed on some estates, of allowing coolies to keep bark-shavings in their lines until they have accumulated a fair quantity, cannot be commended; quite apart from the possibility of actual loss by theft, which is thus rendered easy.

COLLECTION OF EARTH-SCRAP.

It is the proud boast of some managers that the earth-scrap on their estates is almost nil. Without wishing to cavil at the statement the writer confesses himself unable to understand the low percentage of earth-scrap shipped as a distinct grade by some estates. How the formation of an appreciable quantity of earth-scrap rubber can be avoided even under the best of circumstances is not plain. It is granted that during dry weather, and given the fact that cups are often replaced beneath the latex-spout after the latex is collected, the percentage of earth-rubber must be very small. But it often

happens on wet days that latex is washed down the tree-trunk to the ground and, being very dilute, soaks into the earth. It is thus not apparent on the surface, but nevertheless it may be there. Perhaps those estates collecting such infinitesimal percentages of earth-rubber merely take into account that which can be collected from the surface of the ground. Certainly, on some of the best-managed estates, where labour is organised for periodical collection of earth-scrap, the amounts collected are huge in comparison with those of other estates. The ground at the base of the tree below the latex-spout is systematically turned over with pointed sticks and large clots of rubber are often picked up. Here again it is advised that the collected earth-scrap should not be allowed to remain in heaps upon the floor of the factory. It should be placed in suitable tanks containing water; and quite a considerable portion of the cleansing work is thus taken from the machines.

PART II

FACTORY OPERATIONS

CHAPTER VI

PRELIMINARY TREATMENT OF LATEX

RECEPTION OF LATEX AT THE STORE.

BEARING in mind the remarks in Chapter IV. on the conditions under which latex is transported, it follows that nothing but the very best and most suitable vessels should be used in the store. A point to which adequate attention is not given in many factories might be mentioned here. Considering the importance attached to colour in the dry rubber by brokers and consumers, and knowing how extremely trivial are the causes which may mar the colour, it is rather surprising that better provision is not made for the reception and handling of latex in factories. Too often the receiving vessels are placed on the floor of the store close to the entrance. Coolies bringing in latex cannot avoid bringing with them quite a considerable amount of dirt. Presuming that a hose-pipe has been installed, and that the floor is constantly being sluiced down with water, no great harm will result. But would it not be ever so much better if the dirt were kept out? In how many factories is provision made for this? Such an arrangement is not difficult to make, and is already in practice on a few estates. A verandah is built outside the wall of the factory and all latex is received there. In another place open shutes are provided which terminate in the straining sieves. The coolie thus stands on the verandah where he removes coagulated lump and impurities from the latex, which is then poured down the shute, passing through the sieve into large coagulating jars.

Too often it would appear, from the writer's observation, there is a lack of adequate supervision on the arrival of latex at the store. Much can be learned from an inspection of the

coolies' buckets, and the cause of small defects in the finished rubber can often be thus traced. Leaves, stems, bark-shavings, and dirt appear in the buckets, and it is a source of constant surprise to imagine how even unintelligent coolies can allow such things to happen. These objects are removed before or during straining, but still they ought not to be there in the first place, and the fact that such a state of things exists is evidence of neglect on the part of the coolies or lack of supervision. Efforts are made in a large number of cases to cope with these troubles, but on some estates things are allowed to proceed in the same slipshod way, and too much responsibility is thrown on the straining process.

It is suggested that it should be the business of a European to supervise the reception of latex every day. This is at present quite impossible on many estates, but it does not alter the fact that this supervision should be provided, and is extremely necessary.

Need for extreme cleanliness.

Two years ago the local monthly reports repeatedly touched upon the need for improvements in cleanliness. It is extremely gratifying to record that no fault can be found now with perhaps the majority of estates. Still it is surprising how the point is overlooked in many factories; not that they are in a dirty state, but they fall short of being classed as clean factories for want of the little that makes the difference. Possibly those in charge do not believe that all this fuss need be made, but the writer can assure them from a practical knowledge of over one hundred factories that cleanliness does pay.

It might not be credited to Tamil coolies, but yet it is probably true that the moral effect of working under the cleanest and best conditions has an influence upon the store coolies, and that their work is better in consequence. Everything which will tend to simplify the cleansing of the factory should therefore be installed. Hose-pipes, glazed tiles, clean floors, plenty of light and air are not fads or fancies, but considerable factors in determining the final quality of the rubber. There is considerable truth in the suggestion that the coagulating room and machine room should be as spick and span as a modern home dairy.

Straining of latex.

There are some who still believe that too much attention is given to fine straining of latex. The argument is that, presuming the latex is passed through a coarse-mesh sieve and that some object, such as a piece of bark, passes through, it does not really

matter because in machining the rubber the particles of bark will be ejected. It may be that on theoretical grounds this result should be attained, but in practice many could testify that the argument is unsound. Schemes have been devised from time to time by which the ordinary process of straining might be improved upon. One such had an arrangement of combs fitted into a sloping wooden shute. Coarse combs were used at the top end, and other combs of increasing fineness were placed at intervals down the shute. The writer has not had the privilege of seeing such a strainer at work, but it would appear to be quite a good idea, especially as the combs can be removed and replaced in a very short time. It is not known whether the device is actually in practice at present. Another strainer is of a tall conical shape and contains mesh of varying grades at intervals, the coarsest being at the top. It is claimed that by such a strainer the tendency to clog quickly is diminished, and that each or any sieve can be replaced by another in a few seconds.

It is not probable that either of these systems will rapidly displace the simple strainers at present in use. The only real grievance against ordinary sieves is that the mesh breaks so easily. This usually results from the process of rubbing thick latex through owing to the fineness of the mesh, which is usually of the grade known as 30-mesh. For satisfactory average straining this grade is quite small enough. It is true that often fine dirt passes through, but any finer mesh would be impracticable. On some estates it is the practice to pour latex from the buckets very carefully, retaining the dregs in which the fine dust has settled. All these dregs are kept apart and make an inferior grade. It would appear to the writer that this is an unnecessary refinement. Supposing that the fine dust is passed through the sieve it will settle to the bottom of the large jar even after acid has been added, unless coagulation takes place very rapidly. As a rule, if the remaining liquors of the coagulation are examined they are found to contain all the fine dirt, and the under side of the rubber contains none. Where coagulation is extremely rapid in following upon the stirring of acid, it is probable that some of the fine grit would be enclosed in the rubber.

This lesser argument does not affect the main statement that straining should be carried out as thoroughly as possible. The fact that the wire mesh breaks easily is no excuse for pieces of bark, etc., getting into strained latex, as the gauze is not

expensive, and some should always be in stock. A great deal has been heard at various times on the subject of standardising rubber. None would dispute the desirability of this standardisation, and in their own way plantations are slowly but surely working to that end. But before standardisation, one must look for uniformity in the product of individual estates. It is certain that absolute uniformity of any one grade is almost a practical impossibility as the quality of latex varies slightly from day to day. Owing to improved methods, however, this variation is gradually becoming less marked, and a shipment of pale crêpe has been seen in which the daily variation of colour was so slight as to be negligible. As long, however, as the latex from individual fields is to be kept separate there will be slight difference in the production of any one day's rubber. The only practicable way of dealing with the difficulty is by providing a large tank capable of accommodating the latex from the whole estate. With such a system it will be obvious that the crêpe made will be all of one uniform colour and appearance. When dry, the saving of labour now expended in sorting will be great. The system was given a practical test on one estate which erected a large glazed-tile tank, capable of holding 1500 gallons of latex. It was found that the operations of stirring in the necessary quantities of sodium bisulphite and acid could be conducted by means of large paddles. Going through the drying house later, one was struck by the uniformity of the mass of rubber, and it was found in practice that sorting before packing was reduced to a minimum. On a few estates, at present, tanks holding 600 gallons of latex are used, and bulking is effected as far as possible. Unfortunately, the necessity exists on most estates for keeping a strict account of the yields obtained from individual fields or divisions, and hence bulking is impracticable at present. The writer has been working for a considerable period to obtain a satisfactory instrument for testing the specific gravity of latices. It is hoped that with this lactometer it will be possible to make a rapid and accurate estimation of the total rubber content of any known volume of latex. In dealing with latex from separate fields, therefore, it will only be necessary to measure the volume of latex and multiply by a factor which is found by inserting the lactometer in the latex. This should give the number of pounds of dry rubber which will be obtained from that volume of latex. There will then be no necessity for keeping the latex separate.

BULKING OF LATEX AND UNIFORMITY OF PRODUCT.

Once the estimation has been made all the latex may be bulked and a uniform product will result. The final results of the writer's investigations have been sent to makers of the instrument, and a supply should reach the laboratory before this publication makes its appearance.

In the preparation of sheet rubber bulking of latex would be a little more complicated, as it is not possible to mix acid into latex of greater bulk than 50 gallons. After bulking all the latex, therefore, it would be necessary to pour out again quantities of 50 gallons each. This may strike one as being a troublesome business, but if it should save the present wearisome process of sorting by matching colour it will be extra labour well expended. Some such process of gaining uniformity in smoked sheets would appear to be a pressing necessity on a number of estates where there appears to be about four distinct shades of colour in the dry sheets. None can gainsay that such variation is absurd and certainly not required. One factor in the variation of colour in smoked sheet is a very simple one, but yet requires mention. Even to the layman it would appear obvious that the colour of smoked sheet will be influenced by its thickness. Yet in a large number of cases no care is exercised in seeing that uniform quantities of latex go into each coagulating dish. So that even from the same latex it is possible by slipshod methods to obtain sheet showing slight variations in colour.

Addition of water.

One of the greatest reasons why water in the cups should be avoided on most estates is that the quality of the added water is, more often than not, dubious. This objection does not apply, however, to the factory water as a rule, and there would seem to be no reason why good water should not be added to latex if required. One is unable to imagine any but the smallest number of cases where this necessity would arise. In some cases, it is true, latex arrives in the factory so thick that it will not pass through the sieves. Under such circumstances the addition of water would be helpful, and as long as a great excess is avoided no harm can result to the rubber. In some factories it is the practice thus to dilute latex intended for the preparation of crêpe rubber, because a soft coagulum is obtained which is more easily worked on the machines. This dilution of latex is also understood to be an essential feature of a certain process for preparing crêpe rubber. It will be remembered in a previous chapter the writer gave it as his opinion that on some estates the water in the cups alone was four or five times the volume

of the actual latex. The following results of experimental tests on the effect of over-dilution should be studied :—

Samples of crêpe were made, using the following proportions of latex and water, and adding in each case the same quantity of acetic acid :—

E. 27	1 part latex		+ no water.
F. 27	1	"	+ 1 part water.
G. 27	1	"	+ 2 parts water.
H. 27	1	"	+ 4 parts water.

On vulcanisation the following numerical results were obtained :—

	E. 27.	F. 27.	G. 27.	H. 27.
Resiliency	51	50	50	$49\frac{1}{2}$
Resistance to stretching . .	106	103	103	104
Recovery (sub-permanent) .	85·3	84·9	84·7	84·3
Recovery (Admiralty) . .	84·8	84·5	84·2	83·9

It will be noted that in practically all the tests, the quality of the sample falls slightly as the quantity of water increases. This result goes to confirm the idea outlined above, that the use of excessive quantities of water is apparently harmful as well as unnecessary.

It will be seen that there is a distinct difference between the results obtained from pure latex rubber and those from rubber obtained by diluting latex with four times its volume of water. Excessive dilution of latex, therefore, must be avoided.

Addition of acid.

In few factories now is it seen that latex is allowed to stand for any length of time before the addition of the coagulant. The acid should be added as soon as the latex has all been strained, and there is absolutely no advantage in delaying the addition for any length of time after sodium bisulphite has been stirred in. Probably this custom arose from an erroneous idea that the longer the bisulphite was allowed to remain in contact with latex before adding acid, the greater was the so-called bleaching effect, *i.e.* the better the colour of the rubber.

CHAPTER VII

COAGULATION

CHOICE OF COAGULANTS. It is not proposed here to enter into a discussion as to the merits of the dozens of known coagulants. That subject will receive full attention in Chapter XIX. Suffice it to state here that, although the oldest general coagulant, acetic acid still remains the best and safest at the present time, there is a deal to be said in favour of the use of another organic acid, formic acid. It is equally as safe as acetic acid, and quite efficacious; the only drawback is that, taking all things into consideration, it is very slightly more expensive. Acetic acid, therefore, will always be implied in this chapter when the word "acid" is used.

Strength of acid solution. In the old days, *i.e.* about two years ago, it was the rule rather than the exception to find pure undiluted acid used in coagulation. In many cases no harm resulted, for the simple reason that, owing to the large proportion of water in the latex, the acid was thereby very much diluted. Only in one or two non-progressive estates does that custom still hold, and in every case they have to thank the over-dilution of the latex for the non-injury of the resulting rubber.

This argument applies also to the cases where estates still use a comparatively strong solution, *e.g.* 1 part acid to 5 parts water. Most estates make up the stock solution of 1 part acid to 20 of water, and use this with success because of the fair amount of added water present in the latex.

It must be understood that what is being referred to now is not the absolute *quantity* necessary for coagulation, but the *proportions, i.e. the respective volumes of acid and water in the solution of acid made up every day.* That the strength of the acid solution, as well as the quantity used, has an effect upon coagulation can be easily demonstrated in the following way:—

Take separate and equal lots of the same latex, and to each add the same *quantity* of pure acid, but in each case diluted with

varying quantities of water. It will be found that coagulation is quickest where pure acid is employed, and slowest where the acid is most dilute. It will also be found that, providing the quantity of acid employed was sufficient for coagulation, the best and most uniform coagulation is obtained from the use of the most dilute acid, within limits. It will often be found that where pure acid has been employed coagulation is local, *i.e.* we have lumpy coagulation, and often a very milky remaining liquor. This is due to the fact that, as coagulation is immediate upon the spot which is first touched by the pure acid, a deal of the acid is enclosed within the rubber at that spot; and hence other portions of the latex are deprived of acid. It is in such cases that most air-bubbles are enclosed.

As the dilution of the acid solution is increased the mixing is more thorough and uniform. Coagulation is slower and air-bubbles can escape to the surface.

Method of making stock solution.

Experiments have been repeatedly made in the laboratory with acid solutions of varying dilution, from pure acid down to 1 part of acid in 500 parts of water. While it has been found that a 1 in 5 solution can be used where the latex is very dilute (say 1 part of latex to 5 parts of water), and a 1 in 20 solution may be used for fairly dilute latex (say 1 part of latex to 2 parts of water), it is undoubtedly a fact that for latex containing little or no water a much more dilute solution of acid should be used, *e.g.*, 1 in 100, or even 1 in 200 of water. It must be borne in mind that the *quantity of acid* necessary for coagulation is not changed, but merely the dilution. Let us take concrete cases to illustrate the point.

Typical example.

(*a*) Suppose in any factory at present the acid solution is made up in the proportion of 1 pint pure acid to 4 pints water; and that 1 pint of this stock solution is used for every 25 gallons of latex.

If it is now desired to use a stock solution of 1 pint of acid to 50 pints of water, it will be necessary to add roughly $12\frac{1}{2}$ times the quantity of this stock solution, *i.e.* $12\frac{1}{2}$ pints, to every 25 gallons of pure latex, to obtain the same quantity of acid as was formerly used. Thus—

1 to 4; 1 pint necessary for 25 gallons
1 to 50; $12\frac{1}{2}$ pints ,, ,, ,,

(*b*) On another estate at present the stock solution is made up by diluting 1 pint of acid with 20 pints of water, and 1

gallon of this is necessary to coagulate 50 gallons of pure latex.

It is desired to use a stock solution of 1 pint of acid to 100 pints of water. Evidently, therefore, 5 gallons of this stock solution contain only the same quantity of pure acid as 1 gallon of the old solution contained, and it will be necessary to add 5 gallons for every 50 gallons of pure latex. Thus—

1 to 20; 1 gallon necessary for 50 gallons pure latex
1 to 100; 5 gallons ,, ,, ,,

It may be pointed out that the quantities worked out in the foregoing examples are not absolutely and mathematically correct, but they are quite close enough for all practical purposes.

It may be advanced by someone that if a dilute solution of acid, such as 1 in 100, is used the bulk of this stock solution (5 gallons to 50 gallons of pure latex) is very great and might be injurious to the quality of the resulting rubber. A moment's consideration will show that, after all, the volume of acid solution is only one-tenth that of the volume of pure latex. This can have no effect upon the quality of the rubber. Even dilution of the pure latex with half its bulk of water in the factory will have little or no effect upon the quality of the resulting rubber. It is to be remembered that, except in cases where the proportion of added water to latex is absurdly large, the main argument against putting water into the latex-cups is against the possible poor quality of the water rather than against the actual small quantity added. It is acknowledged that, where the water to be put into the cups can be guaranteed to be of good quality no great objection can be raised against placing the smallest possible quantity of such water in the cups. But how many estates have such good water easily available to the coolies, and how many estates can be sure that only that smallest possible quantity is used? It is a notorious fact that, even on estates where the quantity of water used is supposed to be a minimum, the proportion of water to latex in some cups often exceeds even three or four to one. In any case it may be stated as an elementary truism that the absence of water is more to be desired than water of doubtful quality.

Quantity of acid.

As a result of repeated experimental work it has been found that, for pure average latex, the quantity of acid necessary for

complete coagulation, reckoned in parts of pure acid to parts of latex, is—

1 part pure acid; 1000 parts undilute average latex

Where the latex is rather richer than average (above 30 per cent. dry rubber) probably a little more acid would be required, and similarly if the dry rubber content is lower the quantity of acid must be less.

It used to be a common belief that the more dilute the latex the greater the quantity of acid necessary, but this would only apply to cases of extreme dilution of latex.

As a matter of fact, up to certain limits of added water, the reverse is actually the case, *i.e.* the more water in the latex the less acid must be added, assuming that for pure latex the proportion of pure acid to latex is taken as 1 part to 1000 parts. This was found to be the case up to dilutions of three or four times the volume of latex. To take concrete examples which will perhaps make the truth more clear.

Assuming we commence by making up our stock solution of acid by adding 20 parts of water to 1 part of pure acid, this gives us a mixture of 1 to 20. For one gallon of pure latex it would be necessary to add one fiftieth of its volume of the above mixture, *i.e.* $3\frac{1}{5}$ ozs.

Suppose we take a gallon of pure latex and add a gallon of water, we now have two gallons of so-called latex. But we still have only one gallon of real latex present in the diluted latex, and it is only necessary to add sufficient acid to coagulate this gallon, *i.e.* $3\frac{1}{5}$ ozs.

Further, if one gallon of latex be diluted with two, three, or even four gallons of water it is still only necessary to add $3\frac{1}{5}$ ozs. of the acid mixture.

At dilutions beyond this limit, however, it is necessary to add a little more acid to obtain complete coagulation.

This will explain why on some estates the proportion of pure acid to so-called latex often works out at 1 part to 2000 or thereabouts; which is apparently half the strength advised. But it must not be forgotten that in these cases the latex is not pure and contains quite a quantity of water.

In the process of preparing sheet rubber it is very necessary to see that the minimum quantity of acid is used, otherwise visible defects are caused. But in coagulating latex intended for preparing crêpe, where the rubber undergoes protracted washing on the machines, the presence of a slight excess of acid

in coagulation is not calculated to cause any deterioration in the quality of the rubber. Advantage must not be taken of this statement to argue that more than a slight excess may be used without injury to the rubber, as it will be shown that the use of a large excess of acid results in an inferior rubber.

Biscuits were prepared with varying proportions of acetic acid as follows:—

(1) With just sufficient acid.

(2) Twice the necessary quantity.

(3) With thrice the necessary quantity.

The results of tests after vulcanisation were:—

	(1)	(2)	(3)
Resiliency	118	106	107
Resistance to stretching . .	91·5	87·6	87·5
Recovery (sub-permanent) .	58	52½	51½

The differences here shown between sheet rubber prepared with minimum acid and sheets coagulated with excess of acid are so distinct that the point need not be laboured further.

Care in mixing.

In the preparation of crêpe rubber it is sometimes found that two jars containing the same quantity and quality of latex, and coagulated with the same quantity of acid, exhibit differing degree of coagulation. In one jar the remaining liquid will be quite clear, whereas the liquid in the other jar will be more or less milky. This inevitably results from improper mixture of acid with latex in the one case. Generally, it is to be noticed where the acid is used in strong solution. Should the latex be fairly rich, on the addition of strong acid solutions, local coagulation takes place, and a quantity of the acid is enclosed in the local centre of coagulation before stirring can be effected. This mixing is usually attempted with a narrow stick or pole. Keen observers must have noticed that such an instrument is least fitted for intimate mixing, and merely forms eddies. To obtain complete mixing some other instrument must be used, and the best yet seen has the form of a broad paddle.

If local coagulation takes place it follows that the total amount of acid available is reduced, and that the remaining acid is insufficient to coagulate the bulk of latex. Hence the remaining liquid after coagulation will be more or less milky. It is evident, therefore, that considerable care must be exercised in mixing acid and latex for crêpe making.

Much more so does this apply when sheet rubber is to be made; the coagulation must be made as slow as possible so that

the mixture of acid and latex can be bailed out into the dishes before anything like complete coagulation can take place. This point will be discussed further in Chapters VIII. and XV.

Some two years ago a demand for pale crêpe rubbers sprang up, and this demand has been maintained. The total quantity of pale rubber put on the market previously could only have amounted to very little, and that little was obtained by luck and various little tricks in manipulation. It must be premised that if coagulation is allowed to take place either naturally, or with the aid of acetic acid, the resulting rubber will almost inevitably oxidise on the surface except in the cases of very dilute or young latices. Not only will this oxidation take place on the surface; there it is only more evident in the wet rubber. Even supposing that this darkening of the surface does not take place it is often found that a rubber expected to dry to a pale colour does not fulfil expectations, and a dull neutral shade results. This darkening of crêpe rubber may be attributed to a slow process of oxidation which continues until the rubber is dry. From these remarks it will be seen that the process of oxidation is a natural one, and that any pale rubber formerly shipped was the outcome of circumstances outside the control of the estate, except in such cases where boiling of the coagulum, etc., was resorted to. The fact that one rubber happened to be a shade darker than another was absolutely no criterion as to the value of the rubber, but apparently the market thought, and still thinks, otherwise. The prevention of this natural oxidation was a problem which exercised the minds of all responsible for the preparation of pale rubbers, and much time and thought were expended upon it. Various theories were propounded, and the chief conclusion arrived at was that the darkening of rubber was to be prevented by excluding all the light possible from the drying-houses. To this end windows were to be kept shut, or else they were provided with ruby-coloured glass—which kept out the air, incidentally. In spite of these precautions, little success attended the expenditure of so much energy and thought. Meanwhile there was a premium on pale crêpe over smoked sheet, which until then had held first place in favour. It was absolutely necessary that some chemical agent should be discovered which would make the preparation of pale crêpe possible to any estate. This chemical would have to fulfil several requirements before it could become popular:—

USE OF SODIUM BISULPHITE.

1. It must be a simple substance capable of being easily handled.
2. It must be very soluble, so that solutions could easily be made up by inexpert workers.
3. It must be cheap.
4. It must be quite innocent of any harmful effect upon the quality of the rubber.

After months of investigation into the properties of other chemicals the writer decided that the only one which satisfactorily answered all requirements was sodium bisulphite. The writer makes no pretension to any claim of having discovered the properties of this substance, which was a common chemical, and widely known. Even its action on latex was suspected before he engaged upon the work. All that is claimed is that in its extensive practical application to rubber preparation the writer was responsible. These matters are only mentioned because the credit, if any, should be given to the laboratory of the Rubber Growers' Association. It is practically impossible to keep such information private, and the chemical is now in extensive use on nearly all estates whether they belong to the Association or not.

As soon as it began to be known on the market that sodium bisulphite was being used in the preparation of pale crêpe then being sold a great outcry was made, and estates were warned that no more rubber prepared in this way would be accepted. It was said that the chemical would destroy the nerve of the rubber, and it was definitely stated that rubber prepared with this chemical was brittle. It must be remembered that brokers had some legitimate excuse in raising objections to the introduction of new and strange chemicals for preparing rubber, as they were quite without means of judging whether the rubber had suffered harm or not. Still, on the other hand, your chemists had carried out private tests for fully eight months before the name of the chemical was mentioned in their reports, and they had decided from the results of vulcanisation tests that the chemical was quite innocuous. Then, and only then, did they consider it advisable to recommend the use of sodium bisulphite for general estate use.

Effect of bisulphite on vulcanisation of rubber.

Leaving actual practical proofs aside for the moment let us discuss the matter speculatively. Some months ago a manufacturer in England gave utterance to very definite opinions on the use of lime-treated water in the preparation of rubber, and condemned the practice on the ground that lime was an

extremely bad thing to be present in rubber during vulcanisation. It was not stated that lime is sometimes employed in vulcanisation, a fact which is well known to manufacturers. This point apart, and granted that lime when unnecessary in vulcanising exerts an evil influence, how much lime do we expect to find in such rubber? In the first place, lime is not soluble to any great extent in water,—and only the solution was used. Secondly, lime is used only in cases of brown-coloured waters, and this brown coloration is thrown out of solution and precipitated in combination with the lime which was in solution. So that the originally weak solution of lime is rendered still weaker by the loss of the lime carried down by the precipitate. Again the rubber is worked and washed, and if there had been a little lime solution in the coagulum it is thus further got rid of. By the time the rubber is dry, therefore, it would need an exact chemical analysis to detect the merest trace of lime which might be present. Against this put the fact that the manufacturer was thinking of lime in terms of handsful, and one has an idea of the value of such opinions.

From lime let us turn to sodium bisulphite, a substance immensely more soluble than lime and hence much more easily washed out. We treat the rubber with a very small quantity; owing to certain actions which take place between the preservative and the acid the quantity of original preservative is still further diminished, part going off as a gas which has strongly antiseptic properties. Working and washing the coagulum very effectively rids it of any remaining bisulphite, so that we should not expect to find a trace of the substance in the dried rubber, and hence we should also not expect to find any influence exerted during the vulcanisation process.

Coming now to actual proofs of the statement made that the effect of sodium bisulphite is not in the least harmful upon rubber, it may be said that of the dozens of samples tested, prepared with acetic acid and many other coagulants, in no case was it found that rubber had been harmfully affected. As far as could be found the effect was nil, or that it was a beneficial effect. It is not the intention to give the results of all the tests here as they would be too monotonous in character. It will be sufficient only to give figures relating to one or two batches of samples.

1. An interesting batch of samples was received from *Estate No. 26* for purposes of comparison. It comprised :—

(*a*) No. 1 latex crêpe, prepared with sodium bisulphite.
(*b*) Crêpe made from "yellow-rubber" lumps.
(*c*) Crêpe made from "yellow-rubber" lumps submerged in sod-bisulphite.
(*d*) Standard pale crêpe.

NUMERICAL RESULTS.

	(*a*)	(*b*)	(*c*)	(*d*)
Resiliency	64·3	62·4	65·9	58·5
Resistance to stretching . .	137	135	141	124
Recovery (sub-permanent) . .	93·3	91·7	92·4	90·8

Observations.

(1) All the three estate samples are better than standard pale crêpe.
(2) The rubber made from yellow clots, which had been submerged in a solution of sodium bisulphite to prevent oxidation, was better than the rubber which had not been so treated.
(3) The lump-rubber crêpe (*c*) was superior to the No. 1 latex crêpe (*a*); both treated with sodium bisulphite.

2. Samples were submitted from *Estate No. 18*, as follows:—
(*a*) Smoked sheet (ordinary preparation).
(*b*) ,, ,, (with sodium bisulphite).
(*c*) Standard smoked sheet.

NUMERICAL RESULTS.

	(*a*)	(*b*)	(*c*)
Resiliency	67·9	72·2	65·5
Resistance to stretching . .	144	155	140
Recovery (sub-permanent) .	92·0	94·6	94·1

Observation. Both samples from Estate 18 are, on the whole, superior to our Standard Smoked Sheet, and of the two that prepared with sodium bisulphite is much the better.

Enough has now been written to dispose of the idea that the use of sodium bisulphite has any deleterious action upon the rubber prepared with it. Even had we no results of tests upon crêpe rubber prepared with it, the just inference might be made that, if the effect on sheet rubber was as shown above the effect on crêpe rubber, which had been well washed in process of preparation, would be either nothing or beneficial.

When sodium bisulphite was introduced to planters in the writer's local reports Nos. 8 and 9, 1911, the proportions given for use were founded on experimental work carried out upon undiluted latex, and figures were given for such latex which ordinarily oxidises at a rapid rate. It was known that average plantation latices were more dilute, and did not, perhaps, oxidise with such rapidity. In stating quantities, therefore, a maximum was prescribed for this quickly oxidizing undiluted latex, and it was pointed out that proportionately less must be used with ordinary diluted latex. Quantities for use.

This maximum quantity was reckoned at the rate of 1 part sodium bisulphite powder to 400 parts of latex (approximately) to be made up thus:—

(*a*) Dissolve ½ lb. of the bisulphite in 1 gallon of water.
(*b*) Of this solution use 1 gallon to every 20 gallons of latex.

The writer has seen no reason for abating this maximum, but has cause to regret that managers did not use their judgment in considering quantities necessary to prevent oxidation in the latices of their particular estates. The maximum quantity prescribed was used almost universally. No doubt the rubber made had a very fine appearance: in fact, some of the crêpes were too pale. Before long, however, it was found that wherever an excess had been used, the drying period of the rubber was much extended, sometimes by 50 per cent. The remedy lay in the hands of the managers. Sodium bisulphite had not been introduced in order that white crêpe should be made. The sole use for which it was intended was to prevent oxidation, and the quantity for use on any particular estate was that which, by trial, would be found sufficient just to prevent surface oxidation. Any excess, over and above that quantity, was not to be recommended. Gradually this fact began to be recognised, and in course of time it was found on most estates that considerably less sodium bisulphite than the maximum would prevent oxidation and give a rubber which, when dry, would be an improvement on the rubber previouly prepared. The quantity has been decreased on estates to one-quarter, one-sixth, and even one-eighth the maximum quantity recommended. With the decrease in the quantity of sodium bisulphite used, it was found that the retardation of drying was considerably decreased. There can be no doubt that the trouble caused by the prolongation of the drying period in many cases was due to

the abuse of the chemical, and in several cases to the inadequate washing which the rubber received on the rolls. With the incidence of "spot" diseases, to avoid which drying must be hastened, it can be imagined that stores filled with rubber prepared with sodium bisulphite soon began to exhibit symptoms of the disease. This led to the erroneous idea that the chemical was responsible for the appearance of the coloured spots. It will be shown below that this is certainly not the case, and from experience it is now known that the rate of drying was the deciding factor. Not only so, it is actually found that rubber prepared with sodium bisulphite is less liable to "spot" diseases than rubber prepared without it. Daily experiments were made using varying quantities of sodium bisulphite, on the following lines. The results given are typical of those obtained from a series of similar experiments:—

PALE MEDIUM CRÊPES.

Prepared with Minimum Acid and varying quantities of Sodium Bisulphite.

Sodium bisulphite to latex.	Drying period.	Remarks.
1. 1 : 200 (twice maximum)	31	Very pale
2. 1 : 266·6 ($1\frac{1}{2}$ times maximum)	29	,,
3. 1 : 400 (maximum)	23	,,
4. 1 : 533·3 ($\frac{3}{4}$ maximum)	23	,,
5. *1 : 1800* ($\frac{1}{2}$,,)	21	Fine pale
6. 1 : 1600 ($\frac{1}{4}$,,)	21	,,
7. 1 : 2400 ($\frac{1}{6}$,,)	20	Pale
8. 1 : 4000 ($\frac{1}{10}$,,)	20	Dull; some coloured "spots"
9. Blank	19	Very dull; coloured "spots"

It will be seen that there was practically no difference in colour between the first four, although the quantity of bisulphite used ranged from twice the maximum quantity down to three-quarters of the maximum. The difference between the times of drying, however, is quite distinct. In this case one-half or one-quarter the maximum would have been amply sufficient to obtain a good sample of pale rubber; and the difference between the time of drying such a rubber and that of rubber prepared without sodium bisulphite was only two days. Furthermore, it was observed in each day's samples that the crêpes prepared either with the minimum quantity of the chemical or entirely without it were those which suffered from spot disease.

Residual traces of sodium bisulphite.

The prolongation of the drying period was attributed to the fact that traces of substances caused by the decomposition of sodium bisulphite remained in the rubber if the rubber were not sufficiently worked and washed on the rolls. These traces must have been very minute, but they were sufficient to retard the progress of drying. That much depended on the care exercised in washing is evident from the fact that samples prepared with varying quantities of the chemical show varying results on extraction. These samples were tested for the presence of sulphates. Of the series tested that sample prepared with bisulphite in the proportion of 1 part to 600 parts latex showed only a trace of sulphate present; while the one prepared 1 : 2400 gave an equal quantity. Intermediate samples contained no trace of sulphate. On the whole, therefore, the presence of sulphate in crêpe rubber is adventitious, and properly washed crêpe prepared with moderate quantities of bisulphite may be taken as free from any residual quantities. Meanwhile there can not possibly be any doubt of the advantages gained by the use of sodium bisulphite, and it would not be very wide of the mark if the statement were made that, in the event of this chemical being disused, most contracts for pale crêpe could not be fulfilled. When the substance was introduced the cost was calculated at the existing rates on the basis of the maximum quantity. With sodium bisulphite selling at £18 per ton c.i.f. the cost of treatment per pound of dry rubber worked out at $\frac{1}{10}$ of a cent, or $\frac{1}{36}$ of a penny. With sodium bisulphite bought by estates at or about £15 per ton c.i.f., and with quantities decreased to one-quarter or one-sixth the maximum quantity the cost is less than $\frac{1}{150}$ of a penny per lb. of dry rubber. The claim that the chemical would be cheap is amply substantiated, and all the other claims were similarly justified.

THE USE OF FORMALIN.

Although the use of formalin has been discussed in a previous chapter with regard to its use in the field, it may be mentioned again here. For the preparation of sheet rubber it is advisable to delay coagulation as much as possible consistent with subsequent complete coagulation. The practice of adding formalin to the latex in the factory is practically unknown in this country, but such a course might be adopted with advantage on certain days when the latex arrives at the factory slightly viscous. This is done on one or two estates. The solution of formalin is added to the latex before the addition of acid, and is used in the following proportions:—

(*a*) 1 pint of formalin is diluted with 5 gallons of water.

(*b*) Of this solution 1 gallon is added to 50 gallons of latex and well stirred.

With this mixture it is rarely found that the usual quantity of acid is insufficient to effect complete coagulation by the following morning. It is claimed that not only can the latex be ladled out quite entirely without premature coagulation, but also that the sheets are not so liable to air-bubbles. Concerning the latter claim the writer is inclined to accept the statement with reservations.

CHAPTER VIII

PREPARATION OF SHEET RUBBER

THE first form in which plantation rubber was prepared was as "biscuits" or sheets. This form has remained in favour, with intervals of small demand, until the present day, and there can be no doubt that, value for money, it provides the best rubber for the manufacturer. The first biscuits or sheets were rather dark in colour owing to the natural oxidation which followed. Then it was discovered that by diluting the latex the degree of oxidation was diminished, and later it was found that if the soft coagulum were placed in almost boiling water for a short time the resulting rubber was pale. Thus there arose gradually a demand for pale sheet. With our present knowledge we are in a position to state that the pale biscuits were not in any way superior to the darker ones, and they were in most cases actually inferior. PALE SHEET.

It was found also as time progressed that sheet rubber, on air-drying, became covered with external surface moulds, and that, more often than not, the smell of the drying rubber was the reverse of pleasant. Even when dry the sheets had to be continually brushed free from moulds, and by the time the rubber reached the market it was again usually mouldy. Such are, even now, the handicaps under which those who prepare pale sheet to-day have to labour. Few, however, are the estates making pale sheets, and their number is likely to diminish.

To those accustomed only to the preparation of crêpe rubber where coagulation can be effected in large batches, the preparation of sheet rubber always seems to demand much more labour. As a matter of fact, although the preliminary operations certainly do demand more labour than in crêpe making, there are compensating advantages in the machining stage. For the preparation of sheet of the highest quality elaborate installations of machinery are quite superfluous, as equal results could be obtained with a pair of rollers worked by hand labour.

Uniformity of product.

There will be no need to enter here into a discussion of the preliminary operations of receiving and straining latex for sheet making. They have been fully dealt with in Chapter VI. It used to be the general custom to mix the acid and latex in each individual dish, and in a few non-progressive factories that is still the procedure. Quite apart from the question of labour entailed, that process is quite unnecessary. When the large jars are full of strained latex it is now customary to stir in the requisite quantity of acid, and after thorough mixing the latex is dipped out as quickly as possible into the coagulating dishes. It is necessary that the organisation of the labour be good, for unless alacrity is evidenced the chances are that quite a quantity of the bulked latex will begin to coagulate before it is all poured into the dishes. This tendency to coagulate quickly may be overcome by the use of formalin or other agents; but, as a rule, if the operations are properly performed, all the bulked acid and latex is removed successfully.

In the preparation of sheet we have one of the exceptional cases in which the addition of good water to the latex may be justified. Where the latex is rich in rubber it is often found that coagulation takes place too rapidly, and this gives rise to certain defects (see Chapter XV.). Not only so: it is found also that with the usual quantity of latex in the dish the resultant sheet is much too thick and takes excessive time to dry. Even if less latex is put into the dishes and a thinner sheet results, the defects alluded to above are not avoided. The addition of good water is found to ensure a more complete mixture of latex and acid, and in other small ways to be beneficial. Probably it would be much better to put a little formalin into the added water; but in the event of that substance not being attainable pure water has its use. The quantity of water which may be added will vary according to the richness of the latex and the judgment of the operator; but quantities up to one-half the volume of the latex may be used without any apparent injury to the final quality of the rubber. The usual quantity in a dish will then produce a sheet of two-thirds the thickness of previous sheets, and the drying period will be more than correspondingly reduced.

To some managers it has always been a grievance that so much labour attaches to the use of small coagulating pans. The trouble of bulking, bailing, and skimming, and the later work expended in cleaning the dishes and the supporting racks,

have always appeared excessive. Efforts have been made to minimise and concentrate the labour by building large shallow tanks of glazed tiles, capable of receiving large quantities of latex. These tanks may be divided, if required, so as to separate latices from different fields. In these large tanks the acid and latex are mixed by means of wooden paddles, and wooden partitions may be inserted, thus dividing the tank into long narrow compartments. There result long narrow strips of coagulum which may be cut up into required lengths and rolled; or they may be rolled first and cut up later. Theoretically the use of these shallow tanks has much to commend it. By such use a more uniform product is obtained and the operation of cleaning is simplified. Even in practice it works very well and would be excellent were it not for the little defects in construction which sooner or later show up. The glazed tiles begin to crack or fall out and the exposed surface is just the worst to prevent adhesion of the latex. In such case the cleaning of the tanks is no small matter. It is very apparent that either the workmanship of those employed in erecting these tanks is at fault, or else the best way of setting the tiles has yet to be discovered. This is to be deplored as, undoubtedly, the system is a much better one than that of coagulating in separate dishes, and the product is much more uniform. From experience it is found that the best material for embedding the tiles is cement, and the tiles should be placed edge to edge. If the embedding is not done thoroughly and carefully it is found later that "pockets" of liquid collect behind the tiles, and thus the decay of the setting is hastened. But whether separate dishes or one large shallow tank be employed, it is certain that great benefit attaches to the mixture of acid and latex in as large a bulk as possible.

Style of sheet.

Within the last two years the custom of making plain sheet, *i.e.* sheet having a plain surface, has gradually given place to the preparation of ribbed sheet, *i.e.* sheet having a pattern marked on the surface. It would probably be correct to say that plain (smooth) sheet is now only prepared by natives or by estates just come into bearing. Even in the latter case there is no reason why smooth sheet should be made as hand machines are sold which will do all the work required. It will be evident to anyone acquainted with rubber preparation that in the matter of actual quality of rubber the question of smoothness or a pattern can have no bearing on the result. One advantage is

claimed for ribbed sheet which may entirely justify the preference exhibited by consumers, and that is in the question of packing. When rubber arrives at home it is usually found to be in an almost solid block. The smoother the surfaces of the rubber in contact the denser will be the mass, and the greater the difficulty in separating individual pieces. Under such circumstances it is plain that the difficulty is diminished if the sheets have a raised pattern on them. On this ground the "marking" of sheet rubber is to be commended. This reason apart it is really astonishing the difference made in the appearance of the sheets by impressing upon them a ribbed pattern; and it is highly probable that the market value of the rubber is slightly increased. It is not our duty to attempt to reason why this simple operation should increase the market value of sheet rubber: it is sufficient to recognise that it is so, and that money may be thrown away by neglecting to cater for the taste of the market. Of the patterns impressed upon sheet rubber there is a variety, but the general style is that known as the "diamond" mark. This may be effected by a pair of rolls cut with a diamond pattern and running at even speeds, or by a pair of rolls spirally cut in opposite directions. Other patterns are chiefly but varieties of the diamond mark.

BRANDING OF RUBBER.

For some time past it has been suspected that rubber from a few estates commands a higher price on the market chiefly because of its reputation. That is to say, certain estates, having decided upon one form of preparation, maintained that form under fluctuating market conditions, and now receive the recognition which a uniform and staple product deserves. This favour with which the rubber is received is unfortunately a drawback to the estates, inasmuch as there is reason to believe that to supply a demand for these well-known brands inferior rubber of similar appearance may have been supplied to the consumers. Such a practice would be much regretted as it might injure the reputation gained by well-known estates. In order that such a position of affairs may be overcome, it is becoming increasingly necessary for estates to find some way of placing a private mark upon rubber, under which brand alone it should be sold. No satisfactory means of thus marking crêpe have yet been devised, but in preparing sheet rubber the matter is not a difficult one and has been successfully worked out on several estates. The device may be cut upon the marking rolls, and only amounts to a question of mechanical ingenuity. Should there appear to be

any difficulty in the matter the writer would be only too pleased to suggest means to this end.

DILUTION OF LATEX FOR SHEET PREPARATION.

From previous remarks upon the question of dilution of latex it will have been seen that the addition of excessive quantities of water to latex results in a diminution of strength of the resultant rubber. If further proof of this statement be needed the following particulars should satisfy that demand. Samples were prepared and tested as below:—

1. Smoked Sheet: no water added to latex: minimum acid coagulation: smoked 21 days.
2. ,, ,, : latex diluted with 5 times its volume of water; a little extra acid required: smoked 21 days.
3. ,, ,, : latex diluted with 10 times its volume of water: extra acid required: smoked 21 days.
4. ,, ,, : (Standard).

NUMERICAL RESULTS.

	1	2	3	4
Resiliency	68·5	66·5	63·5	65·5
Resistance to stretching .	152·0	145·0	138·0	140·0
Recovery (sub-permanent)	94·3	93·3	91·5	94·1

It is apparent that:—

(a) The smoked sheet from undiluted latex is superior to either of the diluted latex samples and to Standard Smoked Sheet.

(b) The deterioration of quality increases with the dilution.

Having been shown the effects of excessive addition of water, readers may be consoled by the fact that addition of a fairly small quantity of water does not affect the rubber to any appreciable extent. It has been shown, however, in a previous chapter, that on estates where water is allowed in cups the proportion of water to latex is frequently in excess of three or four to one. It is probable, therefore, that the inferiority of sheet rubber prepared by some estates may be directly traced to over dilution of latex. It must be confessed that in laboratory experiments when undiluted latex is obtained it is often found expedient to add an equal quantity of water and to employ a very dilute acid solution in order to obtain uniform coagulation. Otherwise coagulation is often local and incomplete. In the preparation of sheet rubber, there can be no objection to diluting rich

latex with half its own volume of water. Some estates may take advantage of this concession and abuse it. If so the result will be very apparent in the thinness of the sheet rubber, and the consequent poor quality. From one gallon of latex (and water) the sheet should not weigh less than about $1\frac{1}{4}$ lbs. This is calculated from the fact that a gallon of average undiluted latex containing about 30 per cent. of rubber should yield about 3 lbs. of dry rubber. Making all allowances for latex from young trees and for added water (even to the extent of an equal volume) the figure given above is fairly conservative. As a matter of experience it is probable that average estate latex does not contain more than 20 per cent. of dry rubber. Thus a gallon of such latex should yield nearly 2 lbs. of dry rubber if not further diluted. Diluting with an equal volume of water the weight of a single sheet from such latex should weigh about 1 lb. It will probably be found that at this dilution the fresh coagulum will be soft and porous and that the sheet will roll out thin. When suspended for drying, such a sheet is liable to become stretched over the support, and the final shape of the sheet will be narrower in the middle than at the ends.

Thick or thin sheet.

It must be apparent now that the deciding factor in the thickness or thinness of sheet rubber is generally the extent of dilution, and if a thicker sheet is required then the quantity of added water must be decreased. Of course thin sheets can be obtained by decreasing the quantity of latex in each dish, but speaking generally the cause of thin sheets is not to be found in this explanation. It is much easier to alter the thickness of sheets in decreasing quantity than it is to make thicker sheets; and as a rule managers do not seem to appreciate the connection between thinness of sheet rubber and the excessive addition of water in the collecting cups. From a practical point of view it is not desirable to have thick sheets, any more than it is to make thin sheets. If the sheets are thick, drying is very much prolonged, and should pale (unsmoked) sheets be the standard article much trouble is caused by the incidence of moulds. Estates should aim at a sheet of medium thickness which should weigh not less than 1 lb. per gallon of latex; this, of course, will be independent of the various sizes of coagulating dishes. A sheet of this weight and thickness should be fully dried and smoke-cured within twelve days.

When to roll sheet.

For questions of practical economy in factory working it is usual to allow sheet rubber to coagulate overnight, and the

coagulum is rolled early the next morning. It is believed, also, that the longer the coagulum is allowed to stand the better is the physical quality of the dry rubber. Some estates, however, find that their working arrangements are facilitated if the sheet rubber is rolled on the same day as the latex is brought in. Hence the question is often debated as to which method of procedure is the more beneficial to the rubber. A large number of samples have been prepared to test this vexed question, and for the sake of convenience in drying the sheets were all smoke-dried. Varying quantities of acids were used (in all cases acetic acid), and the coagulum was rolled after varying intervals ranging from half an hour after coagulation had begun to twenty hours. This later period terminated the following morning, and is described below as "ordinary" working. The samples prepared and tested were as follows:—

1.	Rolled after ½ hr.	All with minimum acid.
2.	„ „ 2 hrs.	
3.	„ „ 3 „	
4.	Ordinary working	
5.	Rolled after ½ hr.	Twice minimum acid.
6.	„ „ 2 hrs.	
7.	„ „ 4 „	
8.	Rolled after ½ hr.	Three times minimum acid.
9.	„ „ 2 hrs.	
10.	„ „ 4 „	
11.	Ordinary working	
12.	Rolled after ½ hr.	Four times minimum acid.
13.	„ „ 2 hrs.	
14.	„ „ 4 „	
15.	Ordinary working	

Taking the total number of marks obtained by each sample in the vulcanisation tests, and classifying all under the periods elapsing prior to rolling, we have:—

No. of times minimum acid.	Rolled in ½ hr.	Rolled in 2 hrs.	Rolled in 4 hrs.	Ordinary working.
1.	302	313	317	325
2.	302	312	321	—
3.	306	313	314	315
4.	296	302	304	307

Allowing for some variations which may be due to small experimental errors, it is evident from the figures that:—

(*a*) Whether coagulated with minimum acid or with excess of acid rubber left for only a short time is not so good

as rubber which has been allowed to stand for longer periods.

(*b*) Within the limits of the experiment there is a slight increase in quality in proportion to the period of standing.

(*c*) Minimum acid gives the best results.

(*d*) The best result of all is obtained from minimum acid, and the longest period of standing.

It will be seen, therefore, that the ordinary procedure of working is most suitable for the preparation of sheet rubber.

When the coagulum is lifted from the dishes in the morning, it is first rolled by hand in order to consolidate it and to express most of the contained liquids. It is then usual to pass it between the smooth rolls once or twice, and finally it is passed through the cut rolls once in order to impress a pattern upon it. On all modern estates the rolls are run by power, but there is no necessity for this. Some of the best sheet is prepared solely by hand-power mangles and hand-power marking rolls.

Use of sodium bisulphite.

The necessity for preventing surface oxidation in sheet rubber does not exist to the same degree as in the preparation of crêpe, as the vast majority of sheets are smoke-cured. In the preparation of pale sheet, however, the chemical is of great service, and may be used in very small proportions, not exceeding that amount which is just sufficient to prevent darkening of the surface of the rubber. For the preparation of smoked sheet the use of sodium bisulphite is not commended unless a contract is made for pale smoked sheet. At present it would appear that this pale variety is not required, as the buyers have doubts as to whether the smoke-curing has been sufficient. It is worthy of note that if sodium bisulphite is used for the preparation of sheet rubber in the same proportions as it is used for making crêpe rubber, a very prolonged smoke-curing will still leave the rubber a beautiful golden yellow in colour when held between the eye and the light. This would seem to show that the darkening of ordinary smoked sheet is not so much due to the action of smoke as to the rapid oxidation encouraged at a higher temperature. This tendency to oxidise is very much minimised if sodium bisulphite is used. It is interesting to speculate whether this oxidation is of the rubber or of the proteid matter which forms the "insoluble" portion when smoked sheet rubber is dissolved in benzene. There is reason to believe that the oxidation is not of the rubber itself but of the insoluble constituents.

The whole question of smoke-curing versus air-drying of sheet will be dealt with in Chapter X., and it will be sufficient here only to indicate the method of procedure to be adopted if the sheets are to be smoke-dried. It used to be the custom to allow sheet rubber to air-dry first for periods varying from one to several days. Naturally moulds were soon formed, and when the sheets were quite smoke-cured a mass of the dead moulds could be seen, if not over the whole sheet, at least in the corners of each diamond mark. It has been demonstrated in practice that there is no advantage in allowing sheets to air-dry partially before smoking. In fact, to obtain the greatest benefit from smoke-curing, sheet rubber should be placed in the smoke-house as soon as possible. It is recommended, therefore, that sheet be only allowed to drip surface moisture for a few hours before placing in the smoke-house. It is found of considerable benefit on some estates to place the rolled sheets as they are worked off the machines in lukewarm water. From this they are picked out and both surfaces are well scrubbed to remove any fine particles of naturally coagulated rubber which may cling to the surfaces. If coagulation has been perfectly complete, however, this should be unnecessary. Preparation for smoke drying.

Although not in the category of sheet rubber it may be fitting here to note some other forms of smoked rubber, chiefly because they would enter into direct competition with smoked sheet. By some it is believed that plantation sheet rubber is not the most suitable form of preparation for competing with Fine Hard Para. Much time and considerable ingenuity has been expended in devising some mechanical process for imitating on a large scale the principle underlying the process of preparation of "Fine Hard," as it is believed that the best rubber can only be prepared in that manner. The crude methods of the Brazilian serengueiro are known to all, so that there is no necessity to go into the details of the process. Several patents have been taken out for machines which imitate those methods, and it is expected that rubber of quality equal to Hard Para will be obtained. This is extremely probable, in fact, it is almost certain. The principle of all the machines is the same, viz. the formation of successive thin films of latex which are treated with smoke. In some, such as the Wickham machine, latex is poured into a revolving drum, and is thus made to spread a fine coating of rubber. In others, an endless belt is the chief feature. This belt by dipping into latex takes up a thin film which is OTHER SMOKED RUBBER.

coagulated as the belt travels through a chamber filled with smoke. Of this type is the Derry patent which, undoubtedly, is the best of its kind yet put forward. The following criticism of the machine appeared in the writer's local report for May, 1912.

"The principle underlying the process is quite sound, but is not new. It is an extension of the Brazilian process for preparing Hard Para by coagulating thin films of latex in smoke. In this machine an endless belt takes the place of the spindle or paddle employed by the serengueiro of South America. The belt, running over pulleys, dips lightly into a shallow tray of latex, and as the belt travels slowly through a smoke-chamber, the thin film of latex thus picked up is coagulated. This adaptation of the Brazilian process has been proposed by many, including the present writer, who went so far as to send drawings home some eighteen months ago. The idea was abandoned, however, as it was found that, while the machine might be made to work, the rate of production was so small as to render the scheme impracticable.

Rate of production extremely small.

"This is seen to be the case with the machine now under trial. It has two belts each 40 feet in length, and it is only capable of treating about 12 gallons of latex a day, yielding about 15 lbs. of dry rubber, as a maximum.

Consumption of fuel for smoking is high.

"The consumption of fuel necessary for smoking this quantity of rubber is extremely high, and the rubber is quite wet when taken from the belts, thus necessitating either air-drying or smoke-drying.

On a large scale the building would have to be enormous.

"The building which accommodates the machine is about 25 feet long and 9 feet wide. It is obvious, therefore, that for an estate treating 1200 gallons of latex per day, about 4000 feet of belting would be required in a factory of dimensions something like 25 feet by 500 feet at least.

"It would be necessary to instal machinery to drive the belts, and a number of furnaces would be required to generate the smoke. Further, an air-drying house or smoke-house would be required to complete the drying of the rubber. The supply of suitable fuel would have to be extremely great and very cheap.

Is the rubber better than smoked sheet?

"But one of the chief points in any proposed justification of the process would be to prove that the rubber produced was superior to plantation-smoked sheet. It is not proposed here to quote any of our results obtained, but merely to point out that the patentee has supplied no such proof.

The system is apparently impracticable.

"We need not go into the question of comparisons between the relative simplicity of making smoked sheet and the tedious process attached to the machine. Suffice it to say, that the proposed scheme although thoroughly sound in principle is

utterly impracticable in working, and that our sympathy goes to Mr. Derry who has put so much labour and time into so unprofitable an undertaking."

Shortly after the foregoing criticism was written a committee composed of Government representatives and planters was appointed to go into the question of output, etc., of the machine and to make recommendations. As a result of their investigations it was found that unless arrangements could be made for delivery of the rubber at a premium of about 2*d*. or 3*d*. per lb. above the existing rates for smoked sheet the scheme was not then practicable.

As far as can be judged at present a similar disability attends all machines designed to imitate the process of preparing Fine Hard Para. The whole question resolves itself into a consideration of cost of production in comparison with the cost of preparing smoked-sheet rubber.

CHAPTER IX

PREPARATION OF CRÊPE RUBBER

Considering first the preparation of the highest grade, fine pale crêpe, it must be stated that the difficulties attached to the process are generally not sufficiently appreciated. In this pale rubber minor blemishes are so plainly apparent that their importance is highly exaggerated, and what would worthily escape notice in smoked rubber assumes disproportionate prominence in pale crêpes. The very fact that such a delicate material as colourless coagulum has to be manipulated in coarse iron rollers, with the attendant oil and grease worries, should be sufficient to deter one from criticising too harshly the occasional lapses of an estate struggling to give of its best to the market. At the same time there can be no doubt that if precautions are taken to attend to all likely sources of contamination, defects in pale crêpe may be avoided to a wonderful extent.

It is the general custom to commence machining the coagulum as soon as coagulation is complete, and for various practical reasons there is nothing of great weight to be brought against such a practice. At that stage the coagulum is fairly soft and may be easily worked on the rolls, whereas if the rubber is allowed to remain overnight the coagulum contracts and becomes so hard that it has to be cut up into lumps. This introduces the chances of staining by rust from the knives, and renders the actual working much more difficult.

With the idea of obtaining a soft coagulum it is sometimes the practice to dilute the latex to an inordinate extent. It has already been shown (Chapters VI. and VIII.) that excessive dilution is injurious to the physical quality of the rubber. Nevertheless, the fact remains that the softer the coagulum the better the crêpe in appearance, and the more the crêpe is fancied by buyers in spite of a slight inferiority of quality. This slight inferiority is probably quite unknown to the buyers and consumers, who apparently judge rubber only by colour and

general appearance. So that at present there is an anomalous position in which planters may do their best to supply the market with the highest quality, and at the same time know that by doing so they may not receive the highest price for their rubber. No manager could be blamed who agreed with the conclusions of this discussion in theory and went his own way in practice to cater for what the market apparently wants.

THIN, THICK, OR MEDIUM CRÊPE?

Apparently what the market appreciates in good grade crêpe rubber is that it shall be thick, tough, and fairly pale in colour. Buyers have not yet learned that thickness or toughness in the raw crêpe is absolutely no criterion of the physical qualities exhibited by the rubber on vulcanisation. This is a point on which scores of managers need enlightenment also. It almost seems absurd to them to put forward a piece of thin crêpe in comparison with a piece of thick gristly crêpe and to advance that probably on vulcanisation the thin rubber will prove to be superior to the thicker sample. The point they miss is that for testing purposes the rubber is prepared and vulcanised in equal thicknesses. It is quite probable that there will remain some planters and buyers who will never be convinced on this question of thickness of crêpes in spite of proofs.

It is true that in some cases, as will be shown below, the thicker the crêpe the better the physical qualities; but that only refers to thick crêpe which has been prepared originally thick. It might be very pertinently asked why, if the market wants or would like thick tough crêpe, do we not give it? For very sound reasons. In the first place, if a return is made to genuine thick crêpe (originally thick), the period of drying is so protracted that accommodation will be taxed to the utmost. Secondly, the colour on the whole would be inferior to the present standard. Thirdly, we should probably see a virulent outbreak of coloured spots in the rubber. This third reason is really the most important one at present. It is recognised that the only way to guard against "spot" diseases developing is to get the rubber dry as quickly as possible. To this end the rubber must be rolled as thin as possible. When, therefore, the question arises as to whether thin, thick, or medium crêpes are to be made, the manager may not consult the wishes of the market until it is found that local conditions allow of such consideration. There should be no need to remark that the local conditions embrace only those circumstances over which no control has yet been found possible: *e.g.* the incidence of

fungoid and bacterial "spot" disease. At present medium crêpes are liable to be affected by coloured spots only to a slightly lesser degree than thick crêpes, so that nothing but thin crêpe should be made.

Apart from prevailing conditions, the problem has been thoroughly studied and certain definite conclusions have been arrived at. In the first instance to be quoted the following samples were prepared and tested:—

(1) Ordinary thin pale crêpe.

(2) Thick crêpe made by rolling together three or more layers of the previous sample of thin crêpe.

(3) Thick crêpe—made in one thickness. [This crêpe was, therefore, subjected to less severe treatment between the rolls than the two previous samples.]

(4) Thick crêpe prepared by rolling together several layers of a thin crêpe specially prepared; light in colour.

The actual results given were as below. In each case the higher the figure the better the quality of the rubber.

	(1)	(2)	(3)	(4)
Resiliency	53	52½	55½	52
Resistance to stretching (elasticity) .	112	110	112	109
Percentage recovery (sub-permanent) .	89·9	89·8	92·5	89·7
Percentage recovery (Admiralty test) .	93·3	92·4	96·3	93·4

Analysing the above figures the following conclusions are arrived at:—

(*a*) Sample (3), a thick crêpe made originally thick, and subjected to the least working and breaking down on the rolls, gives the best results all round, especially as regards resiliency and elastic recovery after stretching.

(*b*) The thick crêpe (2), made by rolling several layers of thin crêpe together, is slightly inferior all round to the thin crêpe from which it was made. This may be accounted for by the extra working to which it was subjected.

(*c*) The thick crêpe (4), made from specially prepared and very pale thin crêpe, is inferior to the ordinary thin pale crêpe (1).

From these results it would appear that even the slight extra working necessary to build up thick crêpe from thin exerts a harmful influence upon the final quality of the rubber. It is seen that crêpe made originally thick is superior in strength to

thin crêpe. This would appear to be natural, since the rubber has not received such severe treatment on the rolls. There can be no doubt that in the case of machining fresh coagulum the less working the rubber undergoes the better the quality. It is not at all uncommon to find that by the time thin crêpe intended for air-drying is considered to be finished the rubber has been through the various machines a total number of twenty to thirty times. This treatment, though unavoidable in the majority of cases, is warranted to weaken the "nerve" of the rubber slightly. That it is unavoidable is not the fault of the plantations but of buyers, who insist that the rubber shall be given to them with a good surface finish and free from holes. This point will be alluded to again in Chapter XIV, dealing with defects in crêpe rubber.

In further proof of the fact that original thick crêpe is superior to thin crêpe which has received more working, the following two samples prepared on an estate may be considered:—

(1) Thin pale crêpe.

(2) Blanket crêpe, made originally thick.

NUMERICAL RESULTS OF TESTS.

	(1)	(2)
Resiliency	51	56
Resistance to stretching	103	109
Recovery (sub-permanent)	88·5	90·2

In confirmation of the statement that thick-from-thin crêpe is inferior to the original thin crêpe, the results obtained from two estate samples are worthy of note:—

(1) Thin pale No. 1 crêpe; no water in cups.

(2) Thick pale crêpe; from layers of sample (1); excellent colour and general appearance.

NUMERICAL RESULTS.

	(1)	(2)
Resiliency	55·9	54·2
Resistance to stretching	116·3	108·5
Recovery (sub-permanent)	88·3	86·8

Lastly, there are the results obtained from a comparison of thick-from-thin crêpe and original thick crêpe, both samples being specially prepared on an estate to test the point:—

(1) Gristly pale crêpe from thin crêpe.

(2) Original thick crêpe.

NUMERICAL RESULTS.

	(1)	(2)
Resiliency	60	63·5
Resistance to stretching	122	124
Recovery (sub-permanent)	92·4	93·2

In each of the tests the original thick crêpe is superior to the gristly crêpe made from re-rolling layers of thin dry rubber.

EXTENT OF "WORKING."

These points have now been sufficiently treated, and it remains to give actual proof of the statement that the less working rubber receives the better is the final quality. Samples were prepared to test the point, as follows :—

(1) Pale crêpe : minimum acid : 10 times through rolls.
(2) ,, ,, ,, 20 ,, ,,
(3) ,, ,, ,, 30 ,, ,,
(4) Standard pale crêpe.

All three samples were prepared from equal quantities of the same latex, and the rubbers were all rolled three hours after coagulation in order to compare with the ordinary working in an estate factory.

NUMERICAL RESULTS.

	(1)	(2)	(3)	(4)
Resiliency	58·8	56·5	56·4	58·5
Resistance to stretching	123·0	114·9	112·1	124·0
Recovery (sub-permanent)	87·3	82·9	83·3	90·8

It will be noted that while the difference between sample (1) (rolled ten times) and sample (2) (rolled twenty times) is quite distinct, the difference between sample (2) and (3) (rolled thirty times) is but slight. This would seem to show that even rolling twenty times is excessive and causes the rubber to lose "nerve," while any further excess makes very little difference, the damage having already been done. It cannot be doubted, therefore, that one of the chief factors influencing the final quality of crêpe rubber is the amount of working it has undergone, and that the inferior quality of first-grade crêpe from some estates may be accounted for by excessive working. *En passant* it may be remarked that no sample of crêpe has yet been found equal in strength to sheet rubber prepared from the same latex, whether both be air dried or smoke cured. The only important factor influencing this result is that of working, for sheet rubber receives only simple pressure, whereas crêpe is masticated.

It is hoped that from a study of the foregoing discussions it will be clear to managers that a thick crêpe which feels strong to the hand may show a different result on vulcanisation if the

rubber has been prepared by re-working thin crêpe. It should also be plain that, whereas original thick crêpe is the best form of crêpe rubber, there are certain weighty reasons why thin pale crêpe is the only safe form of preparation.

There seems to exist a considerable difference of opinion amongst managers as to what really constitutes thin crêpe, and quite a number of estates ship "thin" crêpe which the writer would classify as medium crêpes. Given normal conditions, a thin crêpe should dry within a period of fourteen days, a medium crêpe within twenty-eight days, and a thick crêpe may possibly take six weeks or more to dry.

STEAMING LATEX.

It was the practice on a few estates not long ago to pass steam into latex with the idea of obtaining a paler colour in the dry rubber. That such was the effect is granted, but unfortunately for the method it brought drawbacks in its train. It is a very singular fact that, although steam coagulation (as it was miscalled, since acid was also added) was also thought to kill off all harmful "germs," the rubber prepared in this way appeared to be more susceptible to attacks of fungoid spot diseases and took much longer to dry than ordinary crêpe prepared with acetic acid alone. It was also found, as the result of vulcanisation tests, that steam-prepared rubber was slightly but distinctly inferior to ordinary crêpe rubber. There are on record three instances proving this.

I. A. Crêpe prepared from latex partly coagulated by steam.
   B. Ordinary crêpe: minimum acid.

NUMERICAL RESULTS.

	A.	B.
Resiliency	52·5	57
Resistance to stretching	85	101
Recovery (sub-permanent)	88·7	93·1
Recovery (Admiralty)	95·5	96·2

It is apparent that ordinary crêpe prepared with acetic is superior all round to rubber coagulated with steam and acetic acid

II. *Samples*:—

A. Ordinary crêpe: minimum acetic acid: latex from five-year-old trees.	All from one estate.
B. Latex from five-year-old trees: coagulated with steam and acetic acid.	
C. Latex from twelve-year-old trees: coagulated with steam and acetic acid.	

Numerical Results.

	A.	B.	C.
Resiliency	55	53	55
Resistance to stretching	110	98	108
Recovery (sub-permanent)	86·7	82·2	86·8

From these results we conclude that the rubber prepared in the ordinary manner by coagulation with acetic acid is superior to rubber prepared from the same latex by steam injection, and equal to rubber prepared by steam injection from latex of much older trees.

III. A. Thick smoked crêpe prepared from coagulated lump rubber.
B. Thin smoked crêpe prepared from skimmings of latex.
C. Smoked crêpe prepared from latex coagulated with steam and acetic acid. Placed in smoke house wet and smoked for seven weeks.

Numerical Results.

	A.	B.	C.
Resiliency	66	68½	57
Resistance to stretching	141	157	106
Recovery (sub-permanent)	93·5	94·6	87·9
Recovery (Admiralty test)	97·0	96·8	

It is to be noted, in spite of the very prolonged period of smoke-curing, the crêpe prepared by coagulation with steam and acid is exceedingly inferior to either of the other two samples. In point of fact, it gives results which are not equal to average air-dried first-grade crêpe rubber. It is not surprising, therefore, that the treatment of latex with steam fell into disfavour, and at the present time it is unlikely that even one estate persists in the practice.

The Da Costa smoking process.

Another form of preparation which had a small vogue for some time was the Da Costa patent smoking process. Most readers must be familiar with the picture of the apparatus which still appears in the advertisement pages of trade publications, although not one is now in use in this country, as far as our knowledge goes. The principle of the machine is the injection of wood-smoke into latex by means of steam. It was claimed that rubber was obtained without the use of acid, but it was forgotten that quite a quantity of acid was contained in the smoke. As a matter of fact, it was found that coagulation was helped by bubble formation upon the surface of the latex, and that the

remaining liquid after coagulation was acid. Although the writer experimented daily with one of these machines it was not until after many trials that the necessary skill in manipulation was obtained. Even then the colour of the dry crêpe rubber was dark on account of the smoke, and furthermore the smell of smoke had disappeared by the time the rubber was dry enough to pack. So that what one really obtained was a rubber spoiled in appearance and unfit for selling as a smoked crêpe.

From what has already been written concerning the effect of passing steam into latex, it will have been expected also that the quality of the rubber prepared by the Da Costa process or any other similiar process would not be equal to that of ordinary crêpe rubber prepared with acetic acid. That this is so is shown in the samples tested as below :—

(1) Crêpe prepared by the Da Costa process.
(2) Crêpe prepared by smoke injection : another process.
(3) Ordinary crêpe : prepared with minimum acetic acid.

NUMERICAL RESULTS.

	(1)	(2)	(3)
Resiliency	51	56·5	57·0
Resistance to stretching	83·5	107	101
Recovery (sub-permanent)	88·5	88·7	93·1
Recovery (Admiralty test)	92·2	94·9	96·2

Finally it may be well to place the better of the two samples of smoke coagulated rubber (No 2) in contrast with an average smoke-dried crêpe, in order to show that the so-called external smoking of crêpe has more effect than the injection of smoke into latex :—

(1) Crêpe from smoke-coagulated latex. Sample (2) above.
(2) Smoke-dried crêpe (average quality).
(3) Standard smoked sheet.

NUMERICAL RESULTS.

	(1)	(2)	(3)
Resiliency	56·5	60·5	66·5
Resistance to stretching	107·0	124·0	147·0
Recovery (sub-permanent)	88·7	82·0	94·1
Recovery (Admiralty test)	94·9	96·7	97·8

There can be no doubt as to the superiority of the smoke-cured crêpe over the smoke-coagulated crêpe, while both suffer in comparison with Standard smoked sheet.

The question of colour in first grade crêpe rubbers is one

COLOUR IN CRÊPE RUBBER.

which has pervaded the whole of the preceding remarks, and has been discussed also in Chapter IV. It is, perhaps, unfortunate that buyers attach so much importance to the question of colour. Possibly the day will soon come when the possession of a pale colour will no longer mean that rubber obtains a higher price. Until that time, it can only be asserted that the colour of first-grade rubber (as long as it is uniform) is no criterion as to the quality of the rubber. In fact, one might go further and state that the very pale colour associated with some fine crêpes should make buyers suspicious of the quality, since this excessive paleness is acquired only by some special manipulation. Some of the means by which practically colourless rubber can be obtained are—

(*a*) Use of excessive quantities of strong acetic acid.
(*b*) Extreme dilution of latex in conjunction with excessive quantities of acid.
(*c*) Extreme dilution in conjunction with steaming and excess of acid.
(*d*) Extreme dilution of latex in conjunction with excess of acid and subsequent heating of the coagulum in hot water.
(*e*) The use of excess of a mineral acid such as sulphuric acid.
(*f*) The skimmings and very dilute latex may be coagulated with excess of acid.

It sometimes happens that a very pale rubber results from the coagulation of latex from very young trees, but one distinguishes this from the foregoing methods.

THE LOWER GRADES OF CRÊPE.

A few years ago it was plain that the lower grades of crêpe (*i.e.* all grades lower than first latex rubber) were not sufficiently appreciated in the market. There was often a difference of 4*d.* or 5*d.* between a first grade crêpe and crêpe made from naturally coagulated lump. This arose chiefly from lack of knowledge. It has since been recognised in some measure that no reason exists for such a wide difference in price, and during the last twelve months the margin between even the first grade rubber and the lowest grade of scrap rubber has been a gradually diminishing one. Providing sufficient care is exercised in the preparation of the lower grades, one should expect to see but very slight difference in prices between any two grades. It is true that adequate attention has been given to the preparation of the scrap grades only from a comparatively recent time, and it is

acknowledged that only two years ago when the price of rubber was abnormally high the lower grades were as often as not prepared in a very slipshod manner. It was quite the common thing to see heaps of bark shavings accumulating on the floor of a factory and generating excessive heat. In the course of experiments the writer found that even with the best grade of wet crêpe rubber, the maximum sun-exposure possible without creating tackiness was about six continuous hours. Now, none would compare the temperature of direct sun-rays with the heat developed in a heap of bark shavings. The hand cannot be held in the latter for longer than a second or two. Yet these heaps were allowed to stand about for a day or days. Is it any wonder then that tackiness was found to develop when the rubber was dry? It is here definitely laid down that no heaps of bark shavings should be accumulated even for half a day. Tanks should be provided in which the shavings should be submerged in water. Preferably the tanks should be shallow. To a lesser degree the same arguments apply to tree-scrap and earth-scrap. Of all grades of crêpe the latter is the one most liable to become tacky in transit. This, to a large extent, cannot be avoided, as old pieces of earth-scrap may be brought in amongst the bulk. Probably these old pieces have been exposed to the sun for days and have become quite resinous. It would be practically impossible to go through all earth-scrap in order to find these odd pieces, but, unless this were done, one could not guarantee that the earth-rubber would always be free from tackiness. The difficulty does not appear, however, on estates where earth-rubber is collected systematically at very frequent intervals.

Bark shavings.

Earth-scrap.

The grade of rubber made from the naturally coagulated lump which forms in buckets and carts is usually of a mixed colour, due to the fact that the lumps oxidise very quickly. When they are allowed to remain overnight before being machined, it can be imagined that the colour of the dry crêpe would be very dark, or would contain very dark streaks. Such is usually the case, but it will be shown later that the question of colour has nothing to do with intrinsic quality, and that generally these crêpes prepared from naturally-coagulated lump rubber are not inferior in strength to crêpe rubbers made by coagulating latex with acid. Providing, therefore, that the coagulated lump is free from bark, leaves and leaf stems, the difference in price between coagulated-lump crêpes and first-grade crêpes should be very slight. Too often, however, not

Naturally coagulated lump rubber.

sufficient supervision is given to the coagulated-lump rubber, and it is common to see it come into the factory containing leaves and bark. These should be picked out before working.

It would seem reasonable to suppose that if some means could be employed for preventing or checking the surface oxidation of naturally-coagulated lump rubber, there would be a corresponding improvement in the colour of the dry crêpe. That such a method is practicable has been demonstrated on several estates. The lump when lifted out of the latex is allowed to drain for a few minutes, and is then (without squeezing) placed in a dilute solution of sodium bisulphite. A 2 per cent. solution would be sufficiently powerful. It is not to be thought for a moment that by the use of sodium bisulphite any previous oxidation will be counteracted; all that is claimed for it is that any further surface oxidation will be checked, and the rubber may be allowed to remain until the next day, for working, if it is so desired. It will probably be found that quite a quantity of latex has been expressed from the lumps by contraction, and to obtain the rubber from this acid may be added. Miracles will not be performed by this method, but the general colour is found to be much improved. Samples of lump-rubber crêpe prepared in this way have been sent to the laboratory, and in one instance the rubber could not be distinguished from a dull first-grade crêpe.

Tree-scrap.

As tree-scrap rubber is a naturally coagulated rubber it should be expected to show up well in quality. This is usually the case; but from what has been said of the effect of sun-heat it will be understood that if trees are not regularly scrapped there is a danger that the crêpes may be found to contain tacky streaks due to the inclusion of old scrap which has been sun-baked. In hot dry weather on widely planted areas tapped on alternate days it has been noticed that scrap remaining for two days often exhibits a resinous appearance and feels sticky to the touch.

If tree-scrap is to be made as a separate grade, as is the general custom, care should be taken to see that it is free from bark and dirt. On some estates where scrap-rubber is paid for per pound collected it is usually the rule to insist that scrap shall be washed free from dirt and picked free of bark. This course is to be commended, but might probably prove impracticable to the majority of estates. Theoretically, of course,

the operation of machining should rid the scrap of all traces of bark; but in practice it does not do so.

THE UNIVERSAL WASHER.

This is a machine which is being gradually installed in all progressive factories. Roughly described, it consists of a heavy trough in which revolve two heavy rollers. These rollers have strong, raised and blunt corrugations which grip the rubber and knead it as it passes through them. The rubber is carried up again by the corrugations, so that the action is automatic.

The rolls do not press tightly against each other, and the raised corrugations are widely set so that there cannot be any excessive working of the rubber and consequent loss of "nerve." The distance between the bottom and side points of the rolls and the inner surface of the trough is such that rubber is kept working up the sides of the trough continuously. It is only necessary, therefore, to put in a charge and attend to the water supply and sluices. Towards the end of the operation, which may take fifteen to twenty-five minutes, hot water may be turned on or poured in. Finally the cleansed rubber is taken to the crêpeing machines. It has been said that unfortunately the machine would not work bark shavings sufficiently, but the writer has seen this material worked very successfully on one estate. That there is an improvement in the appearance of the lower grades of rubber when put through this machine is indubitable, quite apart from the saving of labour effected.

It must also be acknowledged that the machine is very well made. The only apparent complaint one has is against the practice of sending out the machine fitted up. The weight is very great and consequently it cannot be handled with great safety to the machine.

As the rubber is thus worked in a trough of running water it will be seen that all dirt and impurities are washed away. Moreover, the action of the machine is automatic, and the wear upon the ordinary factory rollers is avoided.

The machine is made apparently in several sizes, the largest being size No. 14. This size is generally recommended by the makers, but the writer is convinced that the machine is much too big and expensive except for the very largest of estates or syndicates of estates. Several factories which now have a size No. 14 installed, find only sufficient work to keep it running for more than a few hours per day. Size No. 12 has approximately half the capacity of No. 14. It is capable of receiving and working a charge of about 50 to 70 lbs. of bark-shavings or

earth-scrap every twenty minutes; *i.e.* at the rate of about 180 lbs. per hour. This should be amply sufficient for the majority of estates.

The price of the large size (No. 14) is £450 complete. For substantial packing, suitable for ocean transport and delivery f.o.b. London, another £30 is required. So that by the time the machine is landed in this country the cost will have amounted to over £500. Figures of cost of the smaller size are not to hand, but may be obtained from the makers:—

Messrs. Werner, Pfleiderer & Perkins,
Peterborough,
England,

and others.

BLOCK RUBBER.

Few estates now prepare block rubber, which is essentially crêpe rubber pressed into blocks. In the ordinary process the fresh coagulum is lightly rolled into thin crêpe, which is then vacuum-dried. There are slight variations in the subsequent procedure. Sometimes the rubber as it comes from the vacuum drier is merely allowed to remain on racks overnight before blocking. In other instances the sticky rubber from the vacuum drier is passed once or twice through wet smooth rolls and hung to dry for some days. The dry crêpe is then folded into the pressing box or cut to suit the size of the box. Pressure is applied for some time, and finally the rubber is taken out in one homogeneous mass. Naturally the appearance of the block depends upon the quality of the parent crêpe. Some block rubber is made up thick; other is made in slabs about 3 inches or 4 inches in thickness. With the latter it should be possible, when held up to the light, to see the shape of a hand held between it and the source of light.

It is possible that an erroneous idea of the strength of block rubber has been formed. It should only be necessary to point out that essentially block rubber is merely pressed crêpe rubber. It has been asserted that no crêpe has yet been tested which will equal sheet rubber made from the same latex. It is inconceivable that the mere action of pressing layers of crêpe together would increase the physical quality of the rubber. Hence it would seem to follow that block rubber would not be the equal of sheet rubber prepared from the same latex, and would be inferior to smoked sheet.

The advantages which block rubber possesses are the compactness of the output, its ease of packing, and a saving in freight.

SMOKED CRÊPE.

This subject will be dealt with more fully later, and at present it is intended only to treat it generally. No special precautions are to be observed in preparing crêpe for smoke curing, except that the rubber need not be rolled very thin. It should be cut into lengths not exceeding 4 or 5 feet, as it is sometimes found that the weight of a long length at the temperature of a smoke-house is sufficient to stretch and even break the rubber across the support. It is also found expedient to allow the rubber to air-dry for two or three days before placing in the smoke-house, in order that it shall contract upon itself and better enable it to withstand the heat.

CHAPTER X

DRYING OF RUBBER

It is still the prevailing custom to air-dry crêpe rubbers. A few estates, it is true, now have artificial driers installed, and in some necessary cases others will be erected. But in the majority of cases where money has been expended in building air-drying sheds, as long as it is only possible to ship rubber once a fortnight air-drying is likely to remain in favour. It is a peculiar fact, furthermore, that air-dried rubber is always found to be slightly superior in physical quality to rubber which has been treated in either vacuum driers or hot-air driers. Mention will be made of this again in a later paragraph. It is also to be noted that manufacturers often allow their crêpe rubbers to air-dry and hang for many weeks, as they believe the quality to be improved thereby.

Air-drying crêpe.

The great drawback to air-drying is that one is so dependent upon the weather conditions in this country. In dry weather the rubber dries well, but in a long period of wet weather rubber accumulates at an alarming rate, and the accommodation is sometimes severely taxed. Of course, the rate of drying under normal conditions is totally dependent on the thickness of the crêpe, and every endeavour should be made to maintain a thin style of preparation. If this precaution is not taken the rubber is liable to recurrent attacks of "spot" disease, and one's troubles are very much augmented. This is a disability to which rubber treated in artificial driers is not liable. Still, air-dried rubber can be made equal, if not superior, in appearance to pale rubbers prepared by other processes, and slightly superior in quality.

For the lower grades of crêpe air-drying is always likely to remain the only method, as it would be extremely dangerous to submit them to heat.

Smoke-drying crêpe.

One of the phases of the market which remains a puzzle to the writer is the antipathy shown in general to smoked crêpe. If one fact is certain in the preparation of rubber it is that smoke-curing of crêpe adds considerably to its quality. This

has been demonstrated so often by repeated tests that one has reason to think there must be some unknown prejudice against smoked crêpe. It may be advanced that it is a question of colour, but surely some manufacturers have a use for other than pale rubber. It is acknowledged that of all plantation grades smoked sheet is intrinsically the most valuable, and we maintain that next in order to merit comes smoked crêpe. To give an example of the many proofs obtained, the following results of tests are submitted :

1. Smoked dried crêpe } from one estate.
2. Smoked dried sheet }
3. Standard Smoked Sheet.
4. A good specimen of Fine Hard Para.
5. Standard Pale Crêpe.

NUMERICAL RESULTS.

	1	2	3	4	5
Resiliency	60·5	61·5	65·5	58·5	58·5
Resistance to stretching	124·0	124·0	140·0	116·0	124·0
Recovery (sub-permanent)	92·0	93·3	94·1	91·7	90·8
Recovery (Admiralty) . .	96·7	98·5	97·8	97·8	95·6

It may be noted that:—

(a) Standard Pale Crêpe is but little inferior to Fine Hard Para.

(b) Of the smoked rubbers Fine Hard Para gives the lowest results all round.

(c) Standard Smoked Sheet is much superior to Fine Hard Para.

(d) Smoked Crêpe (1) is distinctly superior to Standard Pale Crêpe.

While it has been remarked that no samples of air-dried crêpe yet tested have shown equality with smoked sheet made from the same latex, it has sometimes happened that smoked crêpe has been found equal and superior to Standard Smoked Sheet. This has generally resulted from some special treatment, such as prolonged smoking. Such instances are given below :—

1. Standard Smoked Sheet.

2. Fine Hard Para.

3. Experimental sample of thick smoked crêpe. In smoke-house for sixty-seven days.

4. Experimental sample of first-grade smoked crêpe : smoked for forty-two days.

5. Sample of thick smoked crêpe prepared from naturally-coagulated lump rubber.

6. Sample of first-grade smoked crêpe.

7. Standard Pale Crêpe.

NUMERICAL RESULTS.

	1	2	3	4	5	6	7
Resiliency	65·5	58·5	70·5	68·5	66·0	68·5	58·5
Resistance to stretching .	140·0	116·0	157·0	152·0	141·0	157·0	124·0
Recovery (sub-permanent)	94·1	91·7	95·6	95·0	93·5	94·6	90·8
Recovery (Admiralty) test	97·8	97·8	97·4	97·3	97·0	96·8	95·6

For these figures it is apparent that in this instance the best result is given by sample (3), the thick crêpe which was smoked-cured for sixty-seven days. It is followed closely by samples (4) and (6), both first-grade smoked crêpes. All these four samples of smoked crêpe, whether first-grade or from coagulated lump, are equal to or superior to Standard Smoked Sheet, and much superior to the specimen of Fine Hard Para which was selected as being a very representative sample. The Standard Pale Crêpe (No. 7) does not compare with the smoked crêpes. It is acknowledged that these particular samples are more than ordinarily good, and that probably average smoked crêpe would not show such a high quality. But there can be no doubt that in general smoked crêpes are superior to air-dried crêpes, the superiority becoming more marked with prolonged periods of smoke curing.

This question of the effect of prolonging the period of smoke-curing is an important one. It is possible to dry thin crêpe in a smoke-house in four or five days, but if smoking for a longer period will improve the quality of the rubber, then it would be preferable to allow the dry rubber to remain as long as convenient for packing and shipping. Experiments have been made to test the point and the results are instructive. Dealing first with the question as to whether prolonged smoke-curing is responsible for any improvement in quality the following samples may be considered:—

Samples:—All crêpes prepared with minimum of acetic acid.

A.	Smoke-dried	to	dryness	only
B.	,,	,,	,,	+ 1 week extra
C.	,,	,,	,,	+ 2 weeks ,,
D.	,,	,,	,,	+ 3 ,, ,,

These samples were medium crêpes and would be smoke-

dried in about eight or nine days. They were put in the smoke-house wet.

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
A	64·5	136·3	94·4
B	65·2	138·8	94·2
C	65·9	139·0	95·1
D	66·5	136·1	95·1

Sample D which received the longest period of smoking is the best sample of the four, but the difference is very small. It is not such a good sample as any of the four mentioned in the preceding test, some of which has been smoke-cured for six or nine weeks.

Another batch of crêpes was prepared from other latex and first air-dried. They were then placed in a smoke-house and treated for varying intervals:—

J. . . .	when fully dry; smoked	1 week.
K. . . .	,, ,, ,, ; ,,	2 weeks.
L. . . .	,, ,, ,, ; ,,	3 weeks.
M. . . .	Standard Smoked Sheet.	

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
J.	62·9	128·4	92·8
K.	67·5	141·5	95·2
L.	68·8	146·8	95·2
M.	65·5	140·0	94·1

Here the results are more definite than in the preceding test, and it is plain that the extra smoking improves a crêpe from an average quality for pale crêpe to a position in which it is superior even to Standard Smoked Sheet. It must be borne in mind that this batch of crêpes was prepared from a different latex to that from which the preceding batch were prepared, so that strict comparisons between the two sets of figures cannot be made.

This brings up the question as to how long rubber should be allowed to hang before placing in the smoke-house. Another batch of crêpes were prepared and treated in the following manner:—

E.	Put in smoke-house 6 hours after crêping	all smoked for 14 days.
F.	,, ,, ,, 24 ,, ,, ,,	
G.	,, ,, ,, 48 ,, ,, ,,	
H.	,, ,, ,, 96 ,, ,, ,,	
I.	,, ,, ,, when about half-dry	
M.	Standard Smoked Sheet.	

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
E.	63·9	129·5	94·0
F.	66·8	133·7	96·0
G.	64·0	134·7	93·2
H.	63·1	135·2	93·8
I.	66·2	139·2	94·7
M.	65·5	140·0	94·1

It is seen that the best sample is that which was allowed to air-dry for twenty-four hours before placing in the smoke-house, and that the half air-dried sample came next in order of merit. No explanation can be offered for this curious fact.

ARTIFICIAL DRIERS FOR CRÊPE.

It is more common to find artificial driers in use in Ceylon than it is in this country. Probably that is because these driers have been in use there for other products. Recently the question of installing artificial driers has received the serious attention of a number of estates in this country, chiefly on account of the incidence of fungoid and bacterial diseases in crêpe rubber. The simple treatment for the prevention of these diseases is to get the rubber dry in the shortest possible space of time. In most cases it is found sufficient to roll crêpe thin for air-drying in order to prevent the appearance of coloured spots. It is found, however, that some drying-houses are so badly planned and constructed that quick drying under even the best of conditions is a practical impossibility. Cases have been known in which the disease may disappear almost entirely during a period of freedom from rain, only to recur as soon as wet weather sets in again. There can be no doubt that, on the whole, the number of cases of "spot" diseases is on the decline; but equally it is certain that some estates will always be liable to outbreaks as long as drying is attempted in existing houses. For these reasons it is a poor policy to temporise, and the only sound policy would be to give up ordinary air-drying in favour of some method of artificial drying. As regards the majority of estates preparing pale crêpe for various reasons, it is not expected that many will instal artificial driers at present. Money has been expended in elaborate buildings which certainly do the work for which they were designed. As long, therefore, as the accommodation is sufficient and fortnightly shipments are the rule, it is expected that ordinary air-drying will still remain the general practice.

Of the better-known artificial driers, there are only three which merit serious consideration in these pages. They are the Passburg vacuum drier, the Colombo Commercial Company's hot-air drier, and the Michie-Golledge process.

The vacuum drier is so well known that only a brief description need be given. It consists of a chamber heated by steam pipes and capable of having the contained air and moisture withdrawn by a pump. This description sounds very simple, and in practice the operation of vacuum drying is really a simple one, and can well be entrusted to an intelligent coolie under efficient supervision. Indicators are fitted which show the vacuum pressure and the pressure of steam in the heating pipes which travel underneath horizontal slabs upon which trays may be placed. Still, in spite of the apparent simplicity of the process, there would appear to be a number of little details which, if overlooked, prove to be factors influencing the result to a considerable degree. Thus it is not uncommon to find complaints that the rubber is not dry when packed. Recently the writer saw rubber taken from a vacuum drier still containing a visible quantity of moisture. One would have imagined that continuous working of the drier would give the experience necessary to obtain dry rubber, but, apparently, such is not the case in a number of instances. Elaborate instructions are given by the makers, but often they are more honoured in the breach than by the observance. Really, there are only two points to bear in mind:— Vacuum driers.

(1) That the rubber must be fairly thin.

(2) That the temperature is not allowed to rise too high. Some makers advise 110° F. as a maximum, but no harm results from a temperature of 130° to 150° as long as the interval is not prolonged.

These two points presume that the vacuum drier is true to its name and that one can obtain a maximum steady pressure. The machines are so well made now that no drier should be taken over from those responsible for its erection unless it can show a vacuum pressure of 28 inches within fifteen minutes of starting the pump; and with the pump stopped there should not be a greater fall in pressure than one inch within ten minutes after stopping the pump.

One of the most frequent sources of error is the control of steam pressure which is responsible for the temperature of the drier. It is quite unnecessary and unwise to maintain any steam pressure once the drying is well under way. All that is necessary is to heat the chamber well before inserting the rubber. As soon as the maximum vacuum pressure has been obtained steam should be shut off from the heating pipes, and it will be found that the temperature is well maintained throughout

the operation with a rise of ten to twenty degrees at the end. If the drier is working at a vacuum pressure of 28 inches, and if the crêpe has been prepared thin enough the rubber should be quite dry within two hours. Should the operation have to be extended to two and a half hours at 28 inches vacuum pressure, it is a sign that the crêpe is too thick. On such occasions it is often noticed that these thicker crêpes are not thoroughly dry, having moist spots. On re-rolling, these moist patches become easily visible, and are a source of great annoyance, inasmuch as they take quite a long time to dry out.

As mentioned before, the crêpe for vacuum drying should be thin. There is no necessity to give it a superfine finish, and the presence of small holes is quite permissible, as they disappear on subsequent re-rolling. The thin crêpe may be folded loosely to the length (or breadth) of the tray several times, but in no other way can the drier be expected to perform its work satisfactorily. Quite recently a case was noted in which thin crêpe was excellently prepared and four or five layers were rolled together for vacuum drying. Naturally this mode of procedure does not give the drier a fair chance, and it would be ridiculous to judge vacuum drying on the results. After two and a half hours at a temperature of 145° F. the rubber appeared to be only about three parts dry, and the subsequent air-drying extended well into a fortnight. It is the common practice to screw up the door of the chamber as tightly as possible. As a rule it is found in course of time that the obtainable maximum vacuum pressure decreases. This may be attributed solely to the screwing up of the door. Around the inside edges of the door are strips of rubber compound, the function of which is to form a tight joint. Should the door be screwed up too tightly these strips become deformed in course of time and slight leaks occur. It should be pointed out that it is only necessary to screw up the door at the beginning of the operation. When the vacuum has been obtained the screw pressure may be released, as the atmospheric pressure outside the chamber is more than ample to keep the door in a close-fitting position. This will be obvious from the fact that the difference in pressure between the inside and the outside of the door amounts to, say, 28 inches atmospheric pressure, *i.e.* nearly 14 lbs. per square foot. By slackening the screw handles, therefore, as soon as the indicator shows the maximum working vacuum pressure, the life of the door joints may be very much prolonged, and the drier will remain efficient for a longer time.

A careful consideration of the question of temperature brings one to the conclusion that the practice of placing a thermometer through the roof of the chamber does not enable one to determine the temperature correctly. In the same way a thermometer suspended behind the observation window cannot indicate the temperature of the rubber, as in both these positions the thermometer must be influenced by radiation from the walls of the chamber. The only position in which the correct temperature could be indicated is between the folds of crêpe. This can be easily arranged so as to enable one to read the temperature from the observation window.

Colombo Commercial Company's drier.

The drier of the Colombo Commercial Co. consists in principle of a number of small chambers or units in which crêpe rubber is placed and through which hot air is passed. As in the case of vacuum drying a great deal depends upon the preliminary treatment of the rubber. If the crêpe is not rolled thin enough drying will be unduly prolonged, with a chance that the rubber will become tacky. The temperature usually obtained is about 150° F., and if the rubber is thin the production of an installation of two chambers should be at the rate of 1 lb. of dry rubber per minute. The usual period of drying is under two hours. One advantage which this drier has over the vacuum-drier is that the chamber can be opened at any time for a short period to withdraw or insert trays. The thin crêpe is folded several times as in the case of vacuum-drying.

Figures obtained from the actual working of a drier in Ceylon are given below:—

Chamber 1.				Chamber 2.
Temperature 160°–180° F.				Temperature 150°–165° F.
No. of tray.	Drying Period.	Weight of wet rubber.	Weight of dry rubber.	
	hrs. mins.			
1	1 22	7½ lbs.	6 lbs.	
2	1 42	7½ "	6 "	
3	1 57	7½ "	6 "	
4	1 57	7½ "	6 "	
5	1 57	7 "	5¾ "	Worked similarly to No. 1. Yielded in 2 hrs. 23 mins. 70¾ lbs. dry rubber from 87½ lbs. wet rubber.
6	1 57	7½ "	6 "	
7	2 0	7½ "	6 "	
8	2 0	7½ "	6 "	
9	2 11	6½ "	5 "	
10	2 11	7½ "	6 "	
11	2 11	7½ "	6 "	
12	2 18	7½ "	6 "	
		88½ "	70¾ "	

It will be seen, therefore, that the drier had an output in 2 hrs. 23 mins. of 141½ lbs., which is at the rate of 1 lb. per minute approximately. The price of such an installation of 24 trays is understood to be Rs. 5000.

As the rubber leaves the driers it resembles vacuum-dried rubber in being surface-sticky. This stickiness is only temporary, and is got rid of by passing the crêpe through wet rolls. Opinions differ as to when this rolling should be given. On some estates the rubber is only allowed to cool a little before passing through the rolls; on others it is given a day or so before rolling. The methods of rolling also differ. In some factories the rubber has been cut to lengths before drying, and these lengths are merely rolled together by simple pressure. Other estates prefer to re-macerate the crêpe while still fairly warm and soft. It is probable that little harm, if any, results from this re-maceration while the rubber is soft, as it is more easily worked in this condition. The thick rubber is then generally hung for a few days to air-dry before packing. As most of the moisture taken up by the dry rubber is surface moisture, three or four days is usually found sufficient for air-drying.

Michie-Golledge system.

The Michie-Golledge system comprises a process of preparation and drying. The latex is diluted with two, three, or four volumes of water and coagulated with acid in a vessel which is rotated with a churning motion. In this cylinder there are curved and fixed blades. The revolving cylinder and its ribs force the latex against the curved blades so as to cause an eddy in the middle of the machine. Here the rubber coagulates and accumulates, the remaining liquor whirling round outside the blades. It can be imagined that with such dilute latex the coagulum is very soft and spongy. This soft mass is passed through a machine which cuts it into "worms" about $\frac{3}{16}$ inch in section. These are placed upon wire trays and dried by means of hot air. The "worms" when dry are re-macerated and built up into medium and thick crêpes. The colour of the rubber prepared by this process is usually very fine, but from what has already been written on the subject of the effect of dilution of latex it may be easily seen that the possibility of obtaining an inferior rubber is not a remote one. When treated in a Colombo drier the "worms" usually require about two hours to dry, so that crêpe rubber may be packed on the fourth or fifth day, as in the case of vacuum-dried rubber.

Presumably there is a certain demand for air-dried sheet,

though why it should be so when smoked sheet can be obtained is not readily understood. Making air-dried sheet is the most simple and crude of all plantation processes, and the employment of the method is usually very evident to the sense of smell. After coagulation in dishes the coagulum is rolled to express as much moisture as possible and the sheets are hung on racks to dry. In the vast majority of cases sheet rubber contains the maximum quantity of impure constituents upon which moulds flourish. It is more common than not, therefore, to find air-dried sheet exhibiting a plentiful growth of moulds. These it is practically impossible to guard against or to get rid of, in spite of repeated brushings; and it is the rule rather than the exception to find that the air-dried sheet arrives on the market covered with mould. AIR-DRYING SHEET RUBBER.

The rate of drying depends largely upon the thoroughness of rolling. With insufficient rolling it is often found that the surface of the sheet dries fairly rapidly and forms a tough skin which makes it extremely difficult for the internal moisture to escape. In such cases sheets often take months in drying, and even then portions are found to be still moist. On the other hand, if thin sheets are prepared and rolled thoroughly and uniformly the rate of drying is often more rapid than in crêpe of the same thickness. This is due to the lumpy formation of the crêpe in spots where the patterns on the two rollers coincide in their action upon the rubber. Hence it will be seen that for properly finishing crêpe the last operation should be one of even pressure on smooth rollers.

It need hardly be pointed out that where rubber takes so long to dry the provision of drying accommodation must be vastly in excess of that needed for smoke-curing the same quantity of sheet-rubber. A sheet which could be smoke-dried in seven days would probably require not less than a month of air-drying.

To those who have followed the arguments set forth in preceding chapters it would seem superfluous to point out again that there is an undoubted improvement in quality of rubber by smoke-curing, whether the rubber is put into the smoke-house wet or after having been air-dried. It will also have been evident that one of the disadvantages of air-drying sheet is the incidence of moulds. Now it is found that moulds cannot develop in smoke-curing; and if they do, then the smoke-curing has been insufficient. The difference in the drying SMOKE-DRYING SHEET.

period also is a strong argument in favour of smoke curing, so that all-round it is seen that there are many valuable advantages to be gained by smoke-curing sheet in comparison with air-drying, and no disadvantages. If proofs are required of the superiority of smoked over unsmoked sheet the reader is referred to page 18, Chapter II.

Air-drying of sheet rubber intended for smoke-curing should not be prolonged to any extent, otherwise moulds form. These certainly die down in the smoke-house, but their presence is always revealed by the rust-coloured masses of hyphæ. It is sufficient only to allow surface water to drip from the sheets in the factory before transferring them to the smoke-house. As it is the general rule to roll sheet rubber in the morning this arrangement fits in very well. The furnaces of the smoke-house are usually extinguished as soon as the sun is well risen, and the rest of the day is occupied in sorting dry sheets. Towards the late afternoon the day's wet sheets can be admitted, and smoking may be commenced as soon as the sun is well in the west, say at half-past four o'clock.

It is the custom on a very few estates to smoke during the daytime and to discontinue smoking at night. As the night-air in this country is usually heavily laden with moisture it will be plain that such a policy is a topsy-turvy one. It is vastly more reasonable to smoke-cure at night; usually the heat of the sun during the day is quite sufficient in itself to promote the drying of rubber, but there is no reason why smoking should not be carried on in the daytime in wet weather, should it be found convenient to do so.

As smoking is done chiefly at night, it should be incumbent upon the management to see that one or two maximum and minimum registering thermometers should be placed in the rubber chamber, so that a check is placed upon the individual in charge of the fires. There still remain a very few smoke-houses in which there is not a thermometer, and it can only be said that those managers are guilty of considerable negligence. It would be wise also to arrange that only the European in charge of the factory operations should possess a thermometer magnet, otherwise there might be a repetition of the farce enacted on one estate, where the store-conductor each morning used to draw down the index to about 100° or 110° F. in obedience to the command that the manager was never to see a higher temperature recorded.

In the question of temperature of drying, it is well to be as strict as possible; not that any great harm will result from a rise of 10° above that recommended, but because the higher the temperature recorded the larger the fires must have been and consequently the more real danger there was of the store becoming ignited. It will be shown later that the temperature giving the maximum benefit of drying and quality was found experimentally to be rather above the temperature usually prescribed for smoke-houses, but in the experimental work there was no danger from fire.

The figure given in previous reports as a maximum working temperature for smoke-houses was 110° F., but certainly the temperature may be as high as 130° if it is considered safe to allow fires to be so arranged. One or two estates are known to work at temperatures of 130° F. and over, in spite of the recommendations of the writer. If those estates care to risk it they may do so, with increased rapidity of drying; but no responsibility can be taken for whatever may happen in smoke-houses where the temperature is allowed to remain as in one case, at 160° F.

Considerable differences are noted in the periods of drying on various estates; but, as there is more than one factor influencing the results, it is not easy at first to find why these differences should exist. Really there are three factors— Period of drying.

(1) Relative thickness of rubber.

(2) Extent of rolling.

(3) Temperature of drying.

It is presumed that the smoke-houses are identical in type and efficiency, and that smoking is in force for the same length of time each day. There need be no discussion of these points; the effect of each is so obvious. The thinner the sheet the quicker the rate of drying; the better the sheet has been rolled the shorter the period of drying; the higher the temperature the more rapid the drying. It is impossible on paper to give an idea of the ideal thickness of sheet rubber because the rolling may not in some cases have been sufficient to consolidate the rubber and squeeze out the maximum quantity of moisture; such a sheet often has a soft spongy feeling. But an average sheet of rubber which has been well rolled should be smoke-dried at a temperature of 120° F. in twelve to fourteen days. If sheets take a month to dry then the three foregoing factors must be examined. By means of raising the temperature it has

been shown that drying is accelerated; but it does not necessarily follow that a sheet smoke-dried in nine days will be equal in quality to another from the same batch allowed to dry more slowly for double the period. Even a sheet which is dry in fourteen days will show an improvement in quality if allowed to remain in the smoke-house for another week or longer. This fact was made evident in the previous chapter in connection with the smoke-curing of crêpe; and samples are sometimes tested which give abnormally high results. In nearly all cases the superiority of such sheets can be attributed to the lengthy period of smoke-curing.

On the other hand, it is often found that thin sheets made from dilute latex of young trees dry so quickly that they are considered to be fully smoke-cured in from seven to ten days. It frequently happens in such cases, however, that the smoking is insufficient, and by the time the rubber reaches home it has begun to show signs of surface moulds. It is evident, therefore, from this discussion that—

(1) If smoked sheet develops surface moulds within a short period after smoking, the duration of curing has been insufficient.

(2) The actual time taken to smoke-dry rubber may be insufficient to smoke-cure it.

(3) There is, within reasonable limits, a continued improvement in the quality of smoked sheet with prolongation of the curing period.

(4) The rate of drying of smoked sheet depends upon—

(*a*) the relative thickness of the rubber,

(*b*) the preliminary treatment of rolling,

(*c*) the temperature of the smoke-house, and

(*d*) the type of smoke-house used. This point will be treated in Chapter XIII.

Fuels for smoking.

The general idea formerly held was that the beneficial effects of smoking were to be attributed to the constituents of the smoke, and chiefly the creosotic substances. This is not now the opinion of the writer, who attributes the effect largely to the temperature of drying and constituents of the smoke other than creosotic substances, *e.g.* formaldehyde. There can be no doubt that the presence of creosotic bodies is responsible largely for the absence of moulds and the existence of the typical odour, but it is becoming increasingly known that the employment of substances rich in creosote is not required or desirable. There is no necessity, therefore, for estates to bemoan the

expense of "bakau" (a mangrove timber rich in creosote) or the fact that they are unable to obtain supplies of coconut husks. Both these fuels, though excellent in themselves, are not indispensable. Any old jungle timber, such as is to be found in abundance on most estates, will supply an excellent source of smoke, especially if treated with small quantities of "bakau" or coconut husks should a stronger odour be required. Any estate doing a lot of pruning or thinning will also find it to its advantage to convey the timber to the vicinity of the smoke-house and stack it to sun-dry. When fairly dry it can be used for creating smoke and serves its purpose excellently.

Other fuels are sometimes used either because timber is scarce, or from choice. Amongst them the chief is old rubber seeds. These give the rubber a distinctive odour which is rather unlike the smell of plantation smoked sheet generally. Other substances used at times have been lallang grass, crushed sugar-cane, and dried cow-dung. A sample prepared with a mixture of seed, lallang, and dry cow-dung had the most distinctive smell the writer has yet experienced with smoked-sheet, and it cannot be said to have raised his admiration. There are one or two patents which have been taken out with the idea of supplying fumes for smoke-curing: they chiefly consist in principle of some means for volatilising creosote. It has already been mentioned that the presence of creosote in quantities is not desirable, and further reference will be made to this subject in Chapter XV. It will be apparent from what has already been written that such patents are hardly worth consideration.

SUN-DRYING SHEET RUBBER.

Among the first curious sights which impress the visitor or new-comer to this country is the spectacle of sheet rubber hanging in the sun on native holdings. From what one has learned of the extraordinary care which must be exercised in all the processes of rubber preparation one fails to understand how such rubber reaches the market without becoming tacky. That some of it does become slightly tacky is certain, but on the whole native rubber, though crudely prepared, is usually sound. The idea of giving sheet rubber a preliminary drying in the sun is to hasten the total period of drying. That the period is curtailed would seem to be the case, but it is open to doubt, as the effect of sun-drying is to create a thin surface film of dry rubber which retards the drying of the rubber below the surface. Working with wet crêpe rubber the writer found that, to all

external appearances, there was no effect upon the rubber when it was allowed to sun-dry for four or five hours. With periods of from six to ten hours the crêpe becomes slightly sticky, chiefly on that portion across the support. When removed to the air-drying house this stickiness developed further, and the rubber, on the line of support, became so weak that it stretched and broke.

Reasoning by analogy it would appear that no apparent harm would result to sheet rubber from sun-drying for periods up to about six hours. Although the point is an interesting one it has little practical application to estate processes, as there would not appear to be any necessity for sun-drying when the work can be accomplished better and more expeditiously by smoke-curing.

ARTIFICIAL DRIERS FOR SHEET RUBBER.

It is understood that when vacuum driers were first applied to the drying of rubber it was thought possible to dry sheet rubber in this way. The practice was found to be impossible, as the length of time required and the temperature were responsible for the destruction of the form of the rubber; it became tacky and semi-liquid.

The "Chula" drier.

Although several vague suggestions of devices for artificially drying sheet have been made, only one is known to be in use at the present time. In the original form this was used for drying other tropical products. It consists of a large iron chamber in which are several compartments divided by means of baffle-plates. At one end there is a small furnace and, by means of a fan, smoke and hot air are drawn through the compartments. Owing to the temperature attained (140°–160° F.) sheet rubber cannot be completely dried in the chambers, and is, as a rule, only treated in this manner for one or two days. Drying is then completed in an ordinary air-drying house. It is claimed that drying is considerably expedited, and that the rubber can be packed in ten days.

In the more recent modification, the smoke and hot air which leave the Chula drier pass through a large room in which may be hung either sheet or crêpe rubber. It would seem that all sources of danger have not been eliminated from the process as on one estate a wooden room containing rubber was ignited by a spark which passed through the drier.

Yet another form exists in which the furnace is outside the main building, and in the ordinary course of working only heats a series of open pipes through which air is drawn by a powerful

fan. By means of a valve it is possible to allow smoke from the furnace to pass into the room with the hot air, for the preparation of smoked rubber. The hot air or smoke is distributed in the lower room by means of main and branch pipes, and passes through an open floor to the room above. With such an arrangement it is possible, therefore, to prepare either air-dried or smoke-cured rubber. If the method could be successfully applied to the drying of crêpe it would be of great assistance. The process has only been in operation for a comparatively short time, and there would seem to be a little difficulty in working it for the drying of sheet rubber and crêpe together, as the temperature suitable for the one is excessive for the other. Given an efficient control over the temperature of the hot air, the house should be successful in the drying of crêpe provided the rubber is not hung in folds of too great length. For smoke-curing sheet rubber the period is reduced by several days in comparison with the time occupied in an ordinary smoke-house, but it remains to be seen whether the rubber so treated is equal in quality to ordinary smoked sheet.

TEMPERATURE OF DRYING.

It has been assumed generally that rubber is best dried at a low temperature, but in the course of observations upon smoke-curing rubber the idea suggested itself that there might be some small range of higher temperatures which would give the maximum benefit to smoked rubber. Naturally the range of temperature is strictly limited by the properties of the substance to be treated, and with a substance such as rubber it would be far better to err on the side of caution than to risk damage to such a valuable commodity.

Experiments were carried out in the laboratory by drying biscuit rubber in a hot-air oven at different temperatures. The results on testing the various samples of rubber thus prepared are extremely interesting. The samples were as follows :—

(1) Biscuits dried at 35° C. (95° F.).
(2) „ „ 40° C. (104° F.).
(3) „ „ 45° C. (113° F.).
(4) „ „ 50° C. (122° F.).
(5) „ „ 55° C. (131° F.).
(6) „ „ 60° C. (140° F.).

NUMERICAL RESULTS.

	Biscuits dried at					
	35° C. (95° F.)	40° C. (104° F.)	45° C. (113° F.)	50° C. (122° F.)	55° C. (131° F.)	60° C. (140° F.)
Resiliency	46	51	53	52	55	45
Resistance to stretching ...	93	104	107	110	114	89
Recovery (sub-permanent) ...	90·6	91·6	91·3	91·7	91·6	89·2
Recovery (Admiralty)	95·2	95·1	95·1	95·1	94·8	94·1

An examination of these figures reveals the fact that the differences on the whole are slight, but that between 55° C. and 60° C. the quality drops away quickly. It is to be remarked also that the Recovery (Admiralty) has a tendency to drop at the higher temperatures. The resiliency value is irregular and not much reliance can be placed upon it in this instance, but the Resistance-to-stretching figure increases fairly regularly up to 55° C. Allowing for possible experimental errors the differences on the whole are insufficient to enable one to make logical deductions. Apparently the best results are obtained at temperatures between 45° C. (113° F.) and 50° C. (122° F.), but it would be wise perhaps to retain our present standard with 120°–130° F. as a maximum for general working. There would seem to be little doubt that the continuous employment of a high temperature is calculated to have harmful effects.

PART III

MACHINERY AND BUILDINGS

CHAPTER XI

MACHINES

The number of manufacturers of machines for preparing rubber would seem to be on the increase, and there can be little doubt that this competition will result in a continued improvement in the design of machines. It cannot be denied that there was room for such improvement, and it is hoped that manufacturers will display judgment in putting only their best quality into the work. While design and finish are very excellent in their way, it is to be regretted that in a number of cases the material of rolls has been found inferior to some of the old rolls. Generally, the complaint seems to be that the rolls are too soft, and that the "grinding" effect is far too great. The damage to pale rubber is considerable, as it is impossible to keep the rolls free from fine dark powder. The effect is generally noticed more in the smooth rolls with which a finish is put upon the crêpe, and so pronounced has the defect been in a number of instances that planters are seriously considering the advisability of seeking rolls of some other material, such as polished granite. These are employed in other industries, and it is probable that they would prove of great benefit as finishing rolls. Unfortunately one is unable to predict whether or not the measure of success would be adequate, and it must remain with some enterprising planter to be the first to experiment in this direction.

In the meantime, cases occur frequently in which rolls have to be returned, because of the injury caused to pale rubber, and there can be little doubt that the life of quite a large number of rolls is far too short in comparison with the expense involved. Judging by the number of cases reported recently it would

appear certain that the quality of material put into the rolls at the present time is inferior to that employed in earlier days.

Not only does this apply to the rolls themselves but also to the brass linings for shaft bearings. Cases are known in which a brass "liner" was so worn within a few weeks as to be quite useless. If the matter ended there it would not be so bad; but there is always the possibility of particles of brass finding their way into trays, and so into the rubber. The damage which ensues to the rubber is quite irreparable. This particular defect arising from the presence of brass will be dealt with in Chapter XIV.

It would be well for managers to remember, therefore, that when machines have to be ordered nothing but the best is good enough, and that the difference between good machinery and passable machinery is probably immensely greater in effect than any saving in expenditure would warrant.

Adequacy of machines.

In general, the factories which prepare sheet rubber are usually equipped with adequate machinery. This arises from the fact that machines are necessary for preparing all grades below the first, even if they are not necessary for the making of sheet. Thus all the necessary macerators and finishing machines are installed, but more than half the output is in sheet form. For the preparation of sheet really no heavy machinery is required; all that is necessary is a hand mangle for rolling the sheets and expressing as much moisture as possible. To obtain a pattern on the sheet another hand-machine may be used. It may be imagined, then, that the work of rolling sheet rubber by power-machines is extremely light, and that a large quantity of rubber can be worked off in a short time. It follows, therefore, that the preparation of the crêpe grades can be proceeded with at once, and that the whole work of the factory is expedited.

The case of factories which have to prepare all first grade rubber in crêpe form is quite different, especially when thin rubber has to be made. The care which has to be exercised in preparing pale crêpe rubber is immense in comparison with what is demanded by sheet rubber. The rubber has to go first through the uneven-speed macerators, from there to the shaping rollers, thence to the finishing rollers. Considerable ingenuity has to be displayed in the arrangement of the machines, so that one section will not work faster or slower than another. More

often than not the attempt to come to such a desirable arrangement fails, owing to an insufficiency of machines. Such a statement will probably read strangely to the uninitiated. But an example will make it plain. A factory may have a battery of six machines, one only of which is a finishing machine. With five other machines working continuously, it will be more than the work of one finishing pair of rolls to keep pace, especially as so much more care has to be exercised in finishing than in rough crêpe making. The obvious course to adopt is to fit another pair of finishing rolls in one of the rough machines; but suppose the factory already has to work all day and well after dark in order to finish the rubber, any such change would be of small benefit. What is really needed in this case is more machinery.

It might be pertinently asked what constitutes an adequate equipment of machines for crêpe making. The writer cannot give a number, but he has no hesitation in stating that if a factory cannot complete its whole day's work before dark it is inadequately equipped. No work should be done after dark, if possible, as it cannot receive the supervision which crêpe-making demands. To make comparison between the number of machines in any two factories and their respective outputs is not sound argument, as the out-turn of two similar machines will depend upon the speed at which the rolls travel, *i.e.* the gearing between the machines and the engines. Thus, while one machine will out-turn 40 lbs. of crêpe per hour, another may only have an output of 30 lbs., although the machines may be identical in pattern. To make calculations based on a rate per hour for any known make of machine, and to apply those calculations to the existing machinery in any factory in an attempt to judge whether there is a sufficient number of machines, would be a mistake, unless one were also supplied with the relative speeds at which the rolls work.

Finally, on the question of adequacy of machines, it must be pointed out an insufficient number of machines must result in a poor product, since all rolls have to be used for all grades. Even with the greatest possible care it happens that pale crêpe is sometimes spoiled because it is contaminated with foreign matter resulting from the working of lower grades on the same machines. This is one of the great arguments, in another direction, for the installation of a "Universal" washer. In any case, it should be possible in any factory to reserve a certain

number of machines for the working of lower grades of rubber alone. If this cannot be done the number of machines is insufficient. In conclusion, the writer can only give it as his opinion that one must not decide the question of adequacy by the number of existing machines, but by the time taken each day in working off the rubber, providing one can be satisfied that the best arrangement of the existing machines has been made.

Lubrication of machines.

It must always appear to those inexperienced in engineering matters that existing methods for lubricating rubber machinery are distinctly crude, when one considers the delicacy of the material to be prepared. The majority of existing machines are still lubricated with oil, which has to be administered in generous quantities. Generally the machines have been so designed that the excess of oil may find an easy passage into the tray which receives the rubber. If not, it just drops outside the tray to the floor and is washed away in great gouts. Even where grease-cap lubricators are fitted it is common to find that the excess often can be transferred from the bearings to the trays and so to the rubber. One would have expected from the attention which is being given to machinery for rubber estates that some improvement in lubrication methods would have been devised.

Trays.

The most absurd fitting on the vast majority of machines, without doubt, is the tray. On nearly all the tray is wider than the effective portion of the rolls, so that any excess of lubricant may drop into it. On others, not only is the tray wider than the rolls, but its edge either is in contact with the shaft of a roll or just a small distance away. The edge of the tray is thus favourably situated for acting as a "wipe," and the lubricant is transferred to the inside of the tray. Considering that the effective portion of rolls is about two-thirds of their length, it must be unnecessary to have trays wider than the length of the rolls. For the preparation of fine crêpe trays are quite superfluous, and their place can be taken by a narrow piece of board if required. If the bed of the machines has been covered with glazed tiles even a piece of board is not necessary. Where trays have been removed from the fine-crêpe rollers on a number of estates, a great decrease in the number of spoiled pieces of rubber has resulted.

Arrangement of

In considering the future arrangement of machines the first care should be to see that machines and windows are to be

found together. Of all the factory operations, rolling of rubber should be given the maximum light. At the same time it would not be advisable always to choose a southern aspect, unless outside shades were supplied. The best position for setting up machines, therefore, is along a wall having a number of windows. This is extremely convenient also from the view of power transmission, and gives the maximum free floor space to the factory. In setting up machines foresight must be displayed; otherwise one may find, when future extensions are made, that the extra machines may obstruct an entry or exit. machines, etc.

For the actual erection of machines no labour should be accepted without European supervision. At present there are machines which are practically useless owing to faulty workmanship, and on many machines bearings run hot for no apparent or explicable reason. Whether the fault lies with the turning of the rolls or the setting of the machine cannot be decided; but at any rate too much care cannot be expended on the supervision of setting up machines.

There is no reason why everything in a factory should not be made as easy to clean as possible. For this desirable condition all machines should have the beds faced with tiles. A word of caution should be given against using marble slabs under the machines, as they would be corroded in time by the slight amount of acid washed out of the rubber. There would be no such objection against the use of white glazed tiles, if they are well set.

In a few factories it has been noticed that the drainage of water from the machines runs to the front of them. This means that the coolies are put to unnecessary inconvenience and discomfort, and they often suffer from sore feet. All water should drain to the back of the machines. The necessity for seeing that these drains are kept clear might then induce those in charge to examine the back of the machines. It is often the case that, while the front of the rolls and tray are kept clean, no attempt is made to cleanse those parts which are not visible or accessible from the front. There should be no need to point out that any labour expended in such "front-window" work is rendered useless by the contamination from accumulations of old rubber and grease at the back of the machines. In the course of visiting factories the writer has many times seen great surprise exhibited by the manager or assistants on being shown the state of affairs at the back of the machines. There

should have been no occasion for such surprise, for the back of the machines is quite as accessible to them as to the visitor.

In conclusion it might be said that the manager needing advice as to the best machines cannot go far wrong in purchasing any of the better-known makes, such as Shaw's, Bridge's, Robinson's, Bertram's, etc. It would be well to judge in the final decision upon—

1. The experience of those already using the machines.
2. Simplicity of parts.
3. Lubrication system.
4. Mode of adjusting rolls.
5. Fitting of trays.

As far as the question of speed ratio between rolls is concerned, there is absolutely no necessity to have higher ratios than two to one for macerators, and for sheet-making machines, of course, the rolls should run at even speeds.

CHAPTER XII

FACTORIES

On the question of general construction there is little to be said, except that buildings are now being properly designed in more permanent form than were some of the earlier buildings. Of these latter it might be said that one or two on well-known estates are not a credit to the companies which own them, and that to expect the management to compete with other more modern and better equipped factories is not just. On the whole, however, there is little fault to be found with factories in general, except in so far as the output has outgrown the accommodation. GENERAL CONSTRUCTION.

Most factories are now erected in iron, but there are a few which are built of bricks. The cost of these does not exceed the cost of iron buildings very greatly and they would appear to be more permanent and much cooler. Whether they will prove more amenable to future extension remains to be seen, but apparently the difficulty, if any, will not be great.

It should be premised that a factory in which rubber is to be prepared should be as light and airy as possible. In this respect quite a number of factories are lacking, and they seem to have been designed to exclude as much air and light as possible. Under these circumstances the building is always dark, there is always an air of dampness, dirt may accumulate, and there is usually a bad smell. Rubber prepared under these conditions is always liable to be below the high standard which should be attained, and the general tone of the factory is depressing.

The old idea that light must be excluded is now known to be erroneous; so that in designing a factory provision should be made for an ample number of doors and windows. In the latter it is quite unnecessary to insert ruby coloured glass. They should be ordinary swing-shuttered windows protected by expanded metal.

It should not be forgotten that in tropical climates iron

buildings may become uncomfortably hot, as some of our factories are. Usually it will be found that the ventilation is imperfect. There is a lack of window space, and the roof is imperfectly ventilated. The ridge of the roof should be opened up by means of a "jack-roof," so that the warm air rising naturally may escape at the highest point of the building.

The floor should be of thick concrete and have a good surface layer of cement. Preferably the floor should not be flat but should slope slightly from the longitudinal middle of the building to the sides on either hand. If the floor is level it usually results in accumulation of water, and the factory always appears to be dirty. All machines should be arranged close to and parallel with one of the long sides of the building and should be raised about six inches above the floor so that water may escape easily. Tanks for the reception of latex, scrap rubber, etc., should be placed along the opposite wall to the machines, and the intermediate length of the building should be entirely free from fixtures. It is not uncommon in older factories to find the engine situated in the middle of the floor, so that what with the space occupied by the engine and the space rendered unavailable by the belt-drive the real accommodation of the factory is sadly diminished. In no modern factory should the engines be brought into the factory. They should always be accommodated in a special compartment situated outside the wall along the inside of which machines are placed. In this way considerable floor space is left available and the machines may be worked by direct drive. Not only so, but if a suction-gas plant is worked there can then be no excuse for particles of coal or charcoal dust being found in the factory. It might be pointed out that if the engines are placed outside the wall which is opposite the machines a long belt-drive would be necessitated, and that the presence of the belt would prevent the use of end doors. It is presumed in these arguments that two engines are to be installed. One can hardly imagine a modern factory being equipped with only one engine, which might possibly have an excess of power necessary to drive all the machines. In the case of a breakdown, which sometimes happens in the best supervised factories, it would be small consolation to know that this excess of power was present theoretically.

There can be no doubt that, taking all things into consideration, the best type of factory is that consisting only of one floor.

The factory should be quite separate from all other buildings, and if attempts are made to conserve ground space by putting a drying room over the factory, much trouble will ensue, especially if pale crêpes are to be made. In the first place the factory is made very much darker, and hence more difficult to keep clean; secondly, the ventilation of the factory is seriously interfered with; and thirdly, it is manifestly prejudicing the drying of rubber to place it directly over a room which is always more or less awash with water. At night when all windows and doors are closed, such a building would reek with a moisture-laden atmosphere, and no drying could be expected to take place in that interval. From actual experience it has been shown that rubber hung to dry in such a room situated over a damp factory is very much liable to attacks of "spot" disease, since the presence of perpetual moisture is favourable to the development of these diseases. If a double-storey building has to be worked it will be readily seen that no first grade rubber should be allowed to dry in it. The accommodation over the factory may be restricted to the purpose of receiving lower grade rubber which is not so liable to "spot" diseases, and does not take so long to dry as first grade rubbers of equal thickness. It is evident, therefore, that the erection of double-storey factories is false economy, as separate drying houses have to be built eventually. This conclusion does not apply with the same force to factories worked in conjunction with smoke-houses for preparing sheet rubber, but one cannot foretell when the demand of the market may force one to prepare pale crêpe in place of smoked sheet.

One of the worst features in many factories is the necessity for coolies to bring latex into the factory. As already mentioned, the floors of factories are usually running with water (or should be), and it can be imagined that the passage to and fro of scores of coolies must bring in a great quantity of dirt. Not only so; the very presence of the coolies is a hindrance to the efficient working of the factory, and considerable floor space and time are wasted. Verandahs.

This feature in factory working is all the more annoying because the necessity for it could so easily be obviated. All that is necessary is the erection of a wide, open verandah outside the wall of the factory. Here all latex could be received and strained, scrap-rubbers could be received and passed through a window into tanks placed in convenient position. Water could be laid on in this verandah so that coolies might wash

their buckets; and the whole verandah might be enclosed only with expanded metal so as to avoid interference with the lighting of the factory. In this way it would be quite unnecessary for any field coolie to enter the factory proper, and this would facilitate cleanliness. Such an arrangement has been discussed by the writer many times during the last three years, but the number of estates which have made such provision can still be numbered on the fingers of one hand; and the same slip-shod and dirt-making procession of coolies continues to walk through the factories; and the same piles of bark-shavings and scrap-rubber continue to accumulate and ferment. The writer, on pointing out these serious defects in working, is constantly being reminded that the fault does not lie with the management, but that the blame attaches to agents and directors who will not sanction expenditure. While he is bound to believe the statement in a few cases, he can hardly believe that agents or directors would be so blind to legitimate and necessary improvements if they were fully aware of the exact state of affairs. Probably they do not realise the importance of these apparently trivial details, and it is hoped that as a result of these remarks all factories will be placed in a position to compete with the most up-to-date and progressive factories.

English designs.

Any discussion upon the planning and erection of factories and factory buildings would not be complete without reference to the mistakes made in all good faith by some companies in sending out factories designed at home by engineers whose experience of estate matters was insufficient. It is quite probable that the cost of these buildings shipped in sections was less than the cost of a similar building in this country, but it is a pity that the design at any rate did not come from an engineer with experience on the spot. Had this been so, ludicrous mistakes would have been avoided, and possibly much expense in the future. One smoke house designed and executed by a home firm was found, when erected, to have a number of ruby-glazed windows in the lower room in which the furnaces were situated. In another the stairs leading up to the rubber room were found to ascend from the smoke chamber. Another smoke house was equipped with quite superfluous chimneys to carry off the smoke, while yet another was equipped with a lift designed to save the carrying of rubber from the rubber chamber. This latter feature would have been sound, but for the fact that the lift travelled down into the furnace chamber. In the course of

erecting a factory sent from home it was found that a large iron "stringer" was planned to run across all the window spaces, and that no provision was made for ventilation in the roof. Probably these instances could be multiplied by cases outside the writer's experience, but sufficient has been quoted to show that in the matter of design at least the experience of those in this country is to be trusted in preference to that of others.

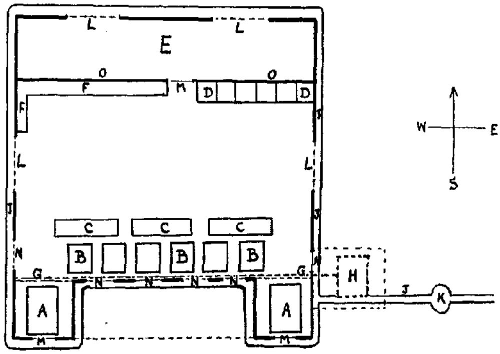
Lastly, there is the question of drains. Generally speaking all factories are well provided with drains, and the only difficulty is that of getting an adequate fall for efficient drainage. But there is a certain amount of laxity exhibited in the matter of providing sieves in drains. To anyone acquainted with factory working it must be apparent that quite a lot of small pieces of rubber are washed into the drains. This rubber should be collected at intervals during the day; but in many instances that collected is only a part of what escapes. Only recently the writer had to call the attention of a manager to this question. As a result a settling tank and screens were installed in the main factory drain and it was found that over a period of one month, the daily loss had been in the neighbourhood of seven pounds. At this rate 2555 lbs. of rubber had been lost per annum; reckoned at 3*s.* 6*d.* per lb., a sum just over £447 had gone down the drains. Undoubtedly this was an exceptional case; but even here there had been screens of a sort in the drains. It is not advanced that factories in general are afflicted with this loss, and the instance is only cited to show how inattention to details may result in considerable loss. Drains.

Summing up, it might be said that a good factory, therefore, should have the following features:—

1. Plenty of windows.
2. A jack-roof in the ridge, and hence a good system of ventilation.
3. Engines in compartments outside the walls of the factory.
4. Machines close to and parallel with the wall outside of which the engines are placed.
5. Latex tanks and other fixtures along the wall opposite the machines.
6. A long middle free space, at either end of which a large double door should be placed in the end walls.
7. A good concrete and cement floor sloping slightly from the middle towards each long wall.
8. An abundant water supply, and several lengths of hose.

9. The building should be of only one floor, and have ample head room.
10. There should be an outside, open verandah upon which latex may be received, etc.
11. The system of drainage should be thorough and the drains should be adequately screened, so that all particles of rubber may be collected.

Rough drawing of suggested arrangement in a suitable factory, embodying the ideas contained in the foregoing suggestions.



EXPLANATION OF DIAGRAM.

A, A. Engines, giving direct drive to machines through line of shafting G, G.
B, B. Machines.
C, C. Wooden tables at the front of machines.
D, D. Glazed-tile tanks for the reception of latex, scrap rubbers, and bark-shavings.
E. Verandah: coolies allowed on the verandah only.
F. Racks for dishes, if sheet rubber is to be made.
G, G. Line of shafting for direct drive.
H. Suggested position for "Universal" scrap washer.
J, J. Drains.
K. Cement settling tank and trap in drain.
L, L. Wide doors.
M, M. Single doors.
N, N. Windows.
O, O. Partition between factory and verandah. A wall, to be only as high as the tanks; above this, if desired, expanded metal.

The outer wall of verandah may be composed of strong expanded metal.

CHAPTER XIII

OTHER BUILDINGS

It has already been shown in the previous chapter that one type of drying-house, viz. that over a factory, stands condemned except for the drying of low-grade rubbers. Generally speaking, a great advance has been made in the design of crêpe-drying houses during the last two years, and it has been possible even to improve older ones so as to bring them into line with the more modern buildings. Houses for drying crêpe-rubber may be of one floor, two floors, or even three floors. Doubtless those built with three floors were designed with a view to economizing the available site for factory buildings, and as long as the ventilation is good there can be no very great objection to them. It might be pointed out, however, that even with the best of ventilation the air passing successively through three layers of rubber must be fairly saturated with moisture by the time it leaves the building. The effect of this upon the rate of drying in the uppermost chamber will not be so marked as it will be in the middle floor, as the temperature of the top floor must be many degrees higher than that of the other two rooms. It would be expected, therefore, that the rate of drying in the middle storey would be slower than that in either of the other two.

DRYING-HOUSES FOR CRÊPE.

In houses of two floors this objection would not have to be met, and drying houses of this type are successful and common. The only stipulation to be made for a house with two stories is that the floor of the upper room should be of an open pattern, so that air may circulate right through the building. This is usually and very successfully attained by laying down wide slats of wood with spaces of an inch or more between them. It is not advisable to have spaces wider than 1½ inches, otherwise there is a certain amount of danger to the limbs of individuals who have to work or supervise in the building. In any case it is very convenient to have pathways of planks running the

whole length of the floor so that the supervision is made more convenient. If this is done there can be no objection to the custom of suspending the rubber of the lower chamber from the slats of the floor of the upper room. At present in some double-storied drying-houses this means of suspension is used but no planks are laid down, and it becomes necessary to walk over the drying rubber. This is a detail, but it is one which does not make for the improvement of rubber, and the expenditure of a small sum would be sufficient to rectify the matter.

There is no doubt in the writer's mind that, given similar systems of ventilation, the best type of drying-house is that consisting of one lofty room, and providing there is sufficient ground space for such a scheme and future extensions, it is the one to be recommended before all others. Quite apart from the question of rate of drying it should appeal also from the fact that with a number of such houses it is possible to isolate any particular kind of rubber; in fact the upper and lower grades may be kept entirely separate. It is realized, of course, that several houses of this type would be more costly to build than a house with two floors, and that for all practical purposes the latter is quite a suitable house for air-drying crêpe-rubber. It can be advanced also that for a small estate, or an estate which will only come into bearing gradually, the two-storied house has an advantage because it provides accommodation in the lower room generally for packing.

No matter how many floors there may be in a drying-house, the greatest attention should be given to the question of ventilation. It is an elementary point in the study of ventilation problems that the best system of natural ventilation is obtained by admitting cool air near or through the floor and providing an exit for the warmer air at the highest point in the building. It is not often that such a rule is infringed in the ventilation of rubber-drying houses, but several of the older buildings erred in this respect. In a good modern house there is a space all round the base of the walls merely closed by expanded metal; this admits cool air. An exit for warm air is provided in the ridge of the roof by either ventilation chimneys or by the jack-roof. The latter is probably preferable, as it provides for a more free escape.

In some drying-houses, besides the ridge openings, the space along the eaves is left open. This would seem to be undesirable, as it provides for the entrance of outer air, which might combat

the ascending warm air and so interfere with the natural upward currents. Provided that a jack-roof or other suitable openings have been installed, there is, therefore, no necessity for the existence of open spaces at the eaves, and they probably do more harm than good.

In this country, on days of sunshine, there must always be an upward current of air in well-designed houses. Temperatures of 105° F. are easily recorded in the ridge space of a building, while the temperature in the lower part of the house may be at least 15° F. lower. On the floor of an upper room a temperature of 90° F. is commonly noted, and in buildings with three stories the usual day temperature of the top room is about or over 100° F. Even, therefore, when there is no trace of a breeze, there must be a displacement of air in an upward direction, though it may not be detected without tests being applied.

It is often asked whether a temperature of 100° F., such as is obtained in the upper room, is calculated to injure the quality of the rubber. There need be no fear on this ground; the experience of many estates goes to show not only that no harm results, but also that the drying of the rubber is expedited. It has already been shown in a previous chapter that the quality of sheet rubber is slightly improved by drying at temperatures over 100° F., within limits, and there would seem to be no reason why crêpe-rubber should not be dried at a temperature of 100° F. It must be understood, however, that higher temperatures for crêpe rubber are not recommended, as it has been proved that the rubber is affected. The fact becomes obvious with continued treatment at temperatures much above 100° F., for the rubber stretches and breaks across the support.

Windows. Concerning the subject of window space in a drying-house there has been much discussion at various times. A few years ago it was common to find windows widely open with the sunshine streaming in. Naturally, tackiness developed in some of the rubber, and care was then taken to keep the windows closed. Thus the rooms were darkened and air excluded. There followed a period in which windows were fitted with ruby-coloured glass to keep out the actinic rays of the sun, which were responsible for tackiness, and excess of light which was supposed to be responsible for the rapid oxidation of rubber. Unless special precautions were observed in the processes of coagulation and preparation, it was not proved that the exclusion of light prevented or lessened the natural oxidation of crêpe-rubber.

Since the introduction of sodium bisulphite for the prevention of oxidation, there has been no cause to worry as to the possible effect of light, as no darkening of the rubber takes place. It follows, therefore, that no trouble need be taken to exclude light, although the necessity for excluding direct sunshine still exists. Windows may be left open as long as the sun does not reach them. This can usually be arranged in a drying-house by manipulating the windows at intervals during the day so that those in the shady side of a building are always open, while those on the sunny side are always closed. If it is thought that this manipulation cannot be entrusted with success to the store coolies, the case may be met by having all windows constructed on the louvre pattern, so that, although the windows are closed all day, air and light are not excluded. Should it be desired to retain the existing type of windows, which open outwards, and to keep them open all day, a simple arrangement of ruby-coloured cloth on an outstanding wooden frame may be placed within the walls of the building. Thus the direct rays of the sun are rendered harmless, while air and light are allowed to enter.

HOT-AIR DRYING HOUSES.

Mention has already been made (Chapter X.) of the existence of a system of drying in which hot air is forced into a drying house by means of a powerful fan. Provided that the temperature of the hot air could be so regulated as not to exceed 100° F. there would be some merit in the system. Such matter of regulation could be very easily solved by having a duct in the main air passage through which cool air could be admitted in such proportion as to modify the temperature of the hot air. As the process is worked at present the temperature attained is well above 100° F., more probably being somewhere about 120°–130° F. Thin crêpe placed in this house over-night is generally found upon the floor in the morning. Unless the crêpe is prepared thick and cut into fairly short lengths it will not bear its own weight; and if it is made thick drying is impracticably prolonged. It is probable that, with a temperature of 100° F., and a steady current of air, average thin crêpe would dry in such a drying house within six or seven days. This would be an improvement upon the usual rate of drying in most factories, although one or two single-floor ordinary drying houses are known in which thin crêpe will dry naturally in that period.

SMOKE-HOUSES.

It is sometimes complained that in case of emergency it is impossible for an estate making pale crêpe to find means for smoking quickly. It is pointed out that the erection of a smoke-

house is a matter of several months' work even when the material is in sight. This is perfectly true as regards the usual permanent form of building, but it might be pointed out that temporary smoke-houses can be cheaply and quickly built of wood and attaps. These temporary buildings, while they last, serve the purpose equally as well as the more expensive iron buildings. Even where the building is to be more than temporary there could be no possible objection to the construction of a wood and attap smoke-house on a small estate or an estate coming into bearing, providing the risk of fire is accepted. Some of the best smoked sheet from this country has been cured in such a wooden building. It is sometimes found desirable to smoke rubber when the only available building is a single-storey one. As a temporary measure the building may be converted into a smoke-house by placing the fires in old kerosene tins sunk into the floor and screened above by galvanised iron baffle plates. But it is not advisable that smoking be continued in a single-storey building, as the best effects are not obtained, and the risk of fire is great.

Smoke houses are usually divided into two types—

(1) Those having external furnaces.

(2) Those having internal furnaces.

The number of the former existing at the present time must be small, as it has been shown that the arrangement of the furnace outside the house is unsatisfactory in comparison with the other type of house, although at a pinch the system is capable of giving fair results. In discussing the question of smoke-houses, therefore, it will be understood that the standard type accepted is that having an internal furnace. In its original form it was known as a "Kent" drier, and consisted of a tall two-storey wooden building. The walls of the lower chamber sloped inwards and downwards from the floor above, so that the lower chamber had the form of an inverted and truncated cone. By this ingenious arrangement it was possible to obtain from one small fire sufficient smoke and heat to cure the product placed in the room above. This is the principle upon which the best smoke-houses in the country are designed. On a very large scale it is not claimed that the sloping sides of the lower chamber lead to economy in the number of fires, but merely divert the smoke in an upward direction. It is found, however, that the space between the sloping sides and a perpendicular may be utilised for the storage of materials which require to be

kept free from damp. At the same time it is acknowledged that the smoking is not interfered with if the walls of the lower chamber are vertical, and it is much simpler to fit in doors. The floor of the lower room may but need not be of concrete and cement. At any rate, the most suitable floor is that liable to cause the least dust. Earth packed hard is found to be quite suitable in most cases. In order to avoid the deposition of wood-ash and dust within the smoke chamber it is advisable to lay down short lengths of rails upon which wheeled furnaces may be run out of the building. This is without doubt the

Furnaces. most suitable form of furnace. It should consist of a shallow iron tray, not deeper than 6 inches, with a bottom grating of fire bars set closely together. Beneath should be another tray about 8 inches deep and closed all round, except that one side may be fitted with a swinging flap hinged above, for the removal of ash. The idea of keeping the sides of the lower tray closed is to avoid an under draught of air in the furnace. Otherwise combustion would be rapid, and there would be more flame than smoke. It is clear that large fires are not desirable, and that combustion must be slow. Hence it is necessary that the combustion tray of the furnace must be shallow, and that the coolies should not be allowed to heap up the fuel. The trolley furnace may be rectangular in shape, and the width should be less than the width of the door of the chamber, so that the whole may be taken outside for the removal of ash.

As a rule the tendency is to supply too many furnaces in a building. It should be quite sufficient to place one for each 25 feet length of the lower room. About each furnace there should be suspended a baffle-plate. This may be made of galvanised sheet iron, and its function is to disperse the smoke and to prevent sparks from passing into the rubber chamber.

Racks. In the upper room bays of racks run at right-angles to a central passage down the length of the building. Narrower passages run between the bays of the racks to facilitate ease in handling and inspection. The wooden supports may be placed about 3 inches apart horizontally, and 15 inches or 18 inches apart vertically. A full bay of racks should contain nine or more lines of support in each of the planes which are 15 or 18 inches apart vertically. The number of these planes is governed only by the height of the room measured from the floor to eaves. The supports should be of smooth timber, and need not exceed $1\frac{1}{2}$ inches square in section.

The floor of the chamber should be of planks, except that the space under each bay of racks must be filled only with expanded metal. With the use of wood fires there is always a large amount of light ash formed, which may find its way into the upper chamber. To counteract this the expanded metal placed across the floor openings should be of small mesh. This gauze may be fitted into a movable wooden frame, so that when it becomes necessary to clean it the whole may be lifted out and a new one substituted for the time being. Floor.

The roof should fit tightly at the eaves, and the only exit for the smoke should be in the roof-ridge. These openings may take the form of a jack-roof, with adjustable swing shutters or circular chimneys fitted with a swinging interior flap, circular in shape. During the operation of smoke-curing these roof openings are to be closed, and they are only opened when it is required to clear the room of smoke for the purpose of inspecting and handling the rubber, or if the temperature of the chamber is found to be too high. The chief point to be observed in smoke-curing is that the smoke shall be in contact with the rubber as long as possible, and in order to obtain this the vent for smoke should be small during the smoking period. Roof.

It usually happens after a house has been working for some time that creosotic substances condense on the under side of the roof and drop upon the rubber, making a distinct blot. To obviate this, coarse sacking should be suspended between the roof and the top of the racks.

Care should be taken to see that the vacant racks are thoroughly cleaned before fresh rubber is placed upon them, otherwise a distinct dirty mark is caused across the middle of the sheet. This mark usually cannot be removed, even by scrubbing with water. Where this mark occurs regularly in all sheets attention should be turned to the openings beneath the bays of racks, and it will generally be found that expanded metal of too wide mesh has been fitted. This should be removed or covered with a much finer gauze, when it will be found that the trouble disappears.

There is no reason why a smoke-house should not be built of brick if desired. The roof might be made of galvanized iron. Naturally, a brick building would be more expensive, and in many districts the scarcity of bricks would make the cost prohibitive. The rough drawings of a smoke-house here shown were made in 1911, and there has been no further advance in

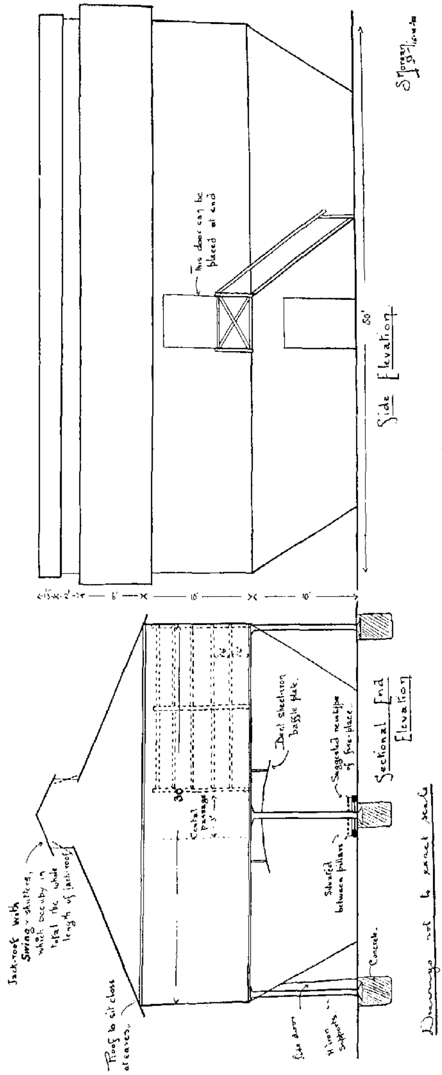
idea since. A building of the dimensions indicated should accommodate from 8000 to 10,000 lbs. of rubber, and the cost should not exceed $4500 (four thousand five hundred dollars = five hundred and twenty-five pounds sterling approximately).

Packing-sheds. Generally, packing has to be done in a small space in one of the drying-houses. There is no objection to this if the space available is sufficient, but more often than not there is not ample room, and sorting and packing are conducted among lengths of hanging rubber. Apart from the question of inconvenience, which delays and increases the cost of labour, there is no reason why such a system should not continue, but time and money would be saved if there was a special room reserved for sorting and packing.

Tool-sheds and store-rooms. The same argument applies to the question of provision for store-rooms. In some factories it is the rule to see lime, cement, spare rolls, sieves, and a general heterogeneous assortment, occupying part of the rubber-drying room. The inconvenience is often great; and it certainly seems that these stores and tools are of sufficient value to be accommodated in suitable buildings.

SITUATION OF FACTORY BUILDINGS. There can be no doubt that a great deal of the "spot" disease trouble and the general slowness of drying can be attributed in many factories to the unsuitability of the site chosen. Probably the idea which actuated those responsible for the choice of site generally was proximity to a water supply. This would account for the fact that a number of factories are situated in valleys or near swamps. More often than not, also, the actual clear space is very limited, and rubber trees grow close up to the walls of the buildings. Under such circumstances it is difficult to see how these buildings can be anything but dark and damp, and it is not difficult to understand the slow rate of drying. In a few cases the sites chosen have proved to be so unsuitable that the estates are confronted with a very serious problem, the solution to which is either the erection of another complete set of buildings in a more suitable spot or the installation of artificial driers.

It must be laid down as an axiom that the first essential in a suitable site is that water may be brought to it easily, and the second, but of equal importance, is that it shall be an ample open space on which the sun may shine all day. There must be no trees too near the buildings, and there should be no adjacent swamps. Preferably, the site should be on a raised



ROUGH DRAWINGS FOR A RUBBER SMOKE-HOUSE.

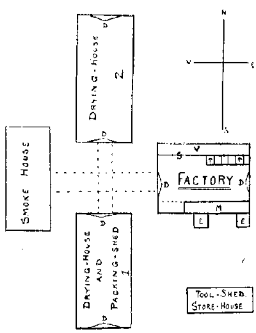
position, so that it will be impossible for surrounding trees to cut off sunshine, even when they are fully grown. From such an arrangement it will follow that the factory will be light and airy, and the drying-houses will receive the maximum of benefit to drying from direct sunshine on the roof and walls. There can be little doubt that these considerations play a most important part in determining the rate of drying of the rubber, and where comparisons are made between the rates of drying in various drying-houses all these factors enter into the question and contribute to the total result. Presuming that the thin crêpes made in two factories are equal in thickness it is not uncommon to find that in a drying-house situated in a wide open space the period of drying may be as low as six or seven days; while in another drying-house situated near a swamp and surrounded by trees the period may be as high as eighteen days to twenty-one days. The figures quoted are not fictitious, but are facts actually noted in the course of the writer's experience.

A great deal also depends upon the exact position of buildings. Thus, to obtain the maximum of light in a factory, it will be obviously beneficial to erect it with the long sides running east and west, so that the windows face the north and south, and the large end doors face the east and west respectively. At first sight it would appear that the best position for the machines would be on the north side of the building where no sun can enter; but a moment's consideration shows that the south side would give the best results. By the time the sun has come round to the south it is usually high in the heavens and the direct sunshine does not fall very far into the room. Even should it play upon the machines for an hour or two during the day no harm could result to the rubber which was being worked, as no piece would remain there a sufficiently long time to be injured in the slightest degree. Placed in this position the maximum benefit of light would be obtained, whereas if the length of the building ran east and west, the machines would have only either the morning or afternoon light.

While it is advisable to erect a factory running east and west, the drying houses should run north and south. In this position the maximum wall area will be exposed to the sun during the day, and it will be possible to manipulate the windows of the drying rooms so that those along one side are open, and it will never be necessary to close all the windows at any time of the day. Thus the windows facing east will be closed, and those

facing west will be open until after mid-day; then *vice versa.* With such an arrangement a more uniform temperature may be obtained than by any other arrangement of the buildings. If the building ran east and west, the windows on the north side could remain open all day, while those facing south would have to remain closed practically all day. The south side of the house would be heated by the sun, while the north side would remain cool, and the rates of drying would be correspondingly unequal. The total wall area heated by the sun at any time of the day would be less in this position than if the house ran north and south.

Similarly, to obtain the best drying effect during the day-time in a smoke-house the building should run north and south. By this means the temperature will be maintained to the maximum possible by sun heat, and the rate of drying will correspond.



Suggested Arrangements of Building

References.

Drying House No. 2 need be only of one storey, while No. 1 may be of two floors, the lower of which can be reserved for packing and sorting.

In the factory—

V shows the position of the verandah, which may be quite open and only divided from the inner room by

S, a wall composed of very strong expanded metal, which allows light and air to enter the factory.

T, T are the glazed tile tanks for the reception of latex, scrap rubbers, and bark shavings.

M shows the position of the machines on the south side of the factory, with the direction of extensions, and

E, E the compartments in which the engines are bedded. In these positions it is possible to obtain direct drive to the machines.

D, D are large double swing or sliding doors (the latter for preference always). These while suiting transport of rubber provide also for a free draught of air.

PART IV

THE FINISHED RUBBER

CHAPTER XIV

DEFECTS IN CRÊPE AND BLOCK RUBBERS

GENERAL FINISH.

In visiting scores of factories the writer has often had occasion to point out one undesirable feature in some pale crêpes. Quite apart from the thickness or thinness of the rubber the difference between the appearance of two crêpes will be most marked when the rubber is half dry. In one it will be seen that drying takes place evenly throughout the length of rubber, whereas in the other large blotches of moisture stand out conspicuously and delay the drying very considerably. This latter type of rubber is nothing less than a nuisance, as it decreases the value of available accommodation and delays shipment of the rubber in fair time. What causes this difference between the two rubbers? This is only one solution which should be self-evident. In a surprising number of cases it has been seen that the solution has not been found. Any solution must be restricted to the rolling process, and it should have been apparent that moist lumps in pale or other crêpes can only be attributed to lack of thorough rolling, especially on the finishing smooth rollers. The fact that rubber finished, or incompletely finished, on diamond, spiral, or other such rolls, has a distinct pattern upon it, and the further fact that this pattern takes longer to dry than the other portion of the rubber, simply go to show that to secure even texture and an even rate of drying plenty of rolling on smooth rolls should be given following upon thorough maceration and washing.

Although theoretically it should be possible to obtain a good surface finish with smooth rolls working at even speeds, it is not always found so in practice, and it is common now to find thin crêpe being finished on rolls travelling at a ratio of 2:1. In

even-speed smooth rolls it is found often that the rubber is torn: *i.e.* it is full of holes. This may be attributed to the fact that the rolls are horizontal, whereas the rubber coming over the front roll has a diagonal tension exerted upon it by the coolie standing in front of the machine.

If a good finish cannot be obtained on the thin crêpe, then it is time the rolls were attended to and changed, or that the ratios of the driving pinions need alteration.

Dirty edges. It seems to be impossible to keep some machines clean, and it is equally difficult to keep the edges of crêpe free from oil and dirt. Usually these dark edges are to be found on crêpe which is rather wide, and it will be noticed that where wide crêpe is made, unless special precautions are taken, the edges of the rubber often pass under the bottom of the hopper and so pick up dirt and oil. On most machines it is a great mistake to attempt the preparation of wide crêpe; nothing but narrow crêpe must be made. To obtain this it is necessary to decrease the width of the hopper placed above the rolls. This can easily be effected by blocks of heavy and hard wood cut to such a shape that when dropped at right angles to the ends of the rolls they remain in position without the necessity of being screwed or bolted on the hopper. As these "cheeks" are capable of being removed in an instant, there can be no excuse for the accumulation of dirt or grease upon them.

Sometimes the dark edges of crêpe are due to another cause. Rolls may be gradually worn in the middle, so that to obtain a good finish it becomes increasingly necessary to tighten up the screws which regulate the distance apart of the rolls. It thus happens that just at and beyond the edges of the rubber the rolls grind upon each other, and fine particles of iron and graphite are transferred to the rubber. In such a case it is evident that either the rolls must be "turned" or that a new pair of rolls must be substituted.

Iron-stains. One of the causes of iron-stain on rubber has been mentioned in the preceding paragraph. This particular kind of iron-stain must not be confounded with rust-stain, and gives a dark dirty colour. It results from the grinding together of the rolls, and is usually noticed in the finishing of fine pale crêpe. For this operation it is necessary to screw up the rolls tightly, and it will be plain that whenever the rolls are vacant of rubber, there is a tendency for them to grind upon each other, thus setting free fine particles of iron and graphite. In order to avoid this

one must be careful to see that between each length of fine crêpe the rolls should be occupied with another piece of rubber, which may be kept for the purpose. In some factories this trouble apparently does not exist, while in others the amount of wear on the rolls is surprisingly great, and the damage done to the rubber is excessive. The only way in which this difference can be accounted for is that there must be a great difference in the quality of the roll material. Some rolls seem to be excessively soft, and from these contamination by iron-stain is great. For this reason rolls are sometimes rejected, and there would appear to be an objection to any but chilled steel rolls.

Rust-stains. Rust-stains, on the other hand, throw the responsibility entirely upon the labour and supervision of the factory. Rust is formed upon the rolls when they are at rest, and any one passing pale rubber between the rolls before they have been thoroughly cleaned is guilty of culpable negligence. Even when apparently clean, a piece of lower-grade rubber should be passed through the rolls several times so as to remove any slight trace of rust remaining.

Rust-stains have also been caused in a few cases by the large knives which are used to cut up lumps of coagulum, or by allowing freshly coagulated rubber to come into contact with iron vessels in the factory.

Oil-marks. The origin of oil-marks in crêpe has already been described in the paragraph on lubrication and trays in Chapter XI. The whole question resolves itself into one of cleanliness, moderation in lubrication, and supervision. The machines should be inspected every day, and once a week rolls should be swabbed down with a 10 per cent. solution of caustic soda applied by means of a piece of cloth fastened round the end of a stick. Immediately after this operation, water should be turned on and the rolls set in motion, so that all traces of caustic soda are thoroughly removed. If possible lubrication by oil should be substituted by grease lubrication through screw caps.

Particular attention should be paid to the back of the machines, and all trays wider than the rolls or high enough to touch or approach the rolls at any point should be thrown out. None but the individual in charge of engines should be allowed to lubricate the machines, and he should be held responsible for any excess of lubricant.

As a rule oil-marks are restricted to the edges or near the edges of crêpe, but sometimes the streak is to be found in the

middle of the length. In such a case it is almost certain that the oil or grease has been picked up by the rubber in the tray. It sometimes happens, if the "liners" of the bearings are eccentrically worn, that a few drops of dirty oil or a particle of grease are squirted out to some distance. These usually find a resting-place in the tray, and the contamination may then appear in any part of the rubber.

Dirt. Streaks due to the presence of dirt are most unusual at the present time, and when they do appear their origin seems to be somewhat of a mystery. It could hardly be advanced that the dirt was picked up on the machines, as it is difficult to imagine where such dirt could come from. In one or two instances there has been fairly clear evidence that the dirt was contained in the coagulum, and the only explanation fitting the case is that it fell into the latex after straining and during the course of coagulation. On cutting open lumps of coagulum brought in from field divisions, it has sometimes been noticed that dirt is included, and the foregoing explanation is the only reasonable one. How it was possible for dirt to get into the latex must be left for explanation to those better acquainted with the conditions under which the latex is coagulated.

Holes. On some estates it would seem impossible, with the existing style of machines, to make really good crêpe. The complaint is that if thin crêpe is attempted it is invariably found to be "full of holes," and as, apparently, the presence or absence of small holes in crêpe rubber is a factor which influences buyers, this defect must be avoided at all costs. Why this matter of small holes in thin crêpe should weigh so heavily with buyers is a mystery which the writer is not in a position to explain. As a matter of fact the presence of small holes is most generally an indication that the rubber has received the minimum amount of working on the rolls consistent with good washing. Further working would only be undertaken with the idea of so consolidating the rubber as to get rid of holes in order to meet the market scheme of valuation.

This may be done by making very thin crêpe (showing holes) and so obtaining dry rubber in a short time. The thin dry crêpe is then re-made by rolling two or more layers together so as to block out the holes. The thicker crêpe is then re-dried in about four or five days.

Or, two layers of thin crêpe, with small holes present, may be rolled together when wet, with the same idea.

If the latter course is adopted it will be found that the period of drying is considerably lengthened, and this constitutes a very serious drawback. The former method, therefore, is preferable; but it will generally be found that if experiments are made in altering the ratio of the driving pinions of the rolls success will eventually be achieved. No definite rule can be given, but some estates have succeeded by superseding even-speed rolls and installing uneven-speed pinions. Sometimes the roll which travels more slowly is at the front, in other cases it is at the back.

Green streaks in crêpe rubber.

Up to a comparatively recent date no case had been reported of green and tacky streaks in pale crêpe. The first case which was submitted provided food for thought, and in the course of the investigation some new and curious facts were observed. There was apparently nothing used on the estate or in the store which could have been the source of the copper. Yet there could be no possible doubt that copper was the cause of the defect.

The case promised to be a mystery until an examination of the machines supplied a possible solution. It was seen that the machines were of the old hand-oiling type and were much worn. The cog-wheels driving the rollers were so worn that one set of teeth touched the bottom of the corresponding space on the other wheel, in the normal position of the rollers. The result was that the rollers could be tightened up for closer work only on one end. This naturally put the rollers out of alignment with the brass bushes, causing a heavy grinding action on the bushes. If it were possible that small particles of brass could pass over to the rollers we have at once an explanation of the presence of copper.

Particles of brass transferred to the rollers.

By what means could these particles of brass have been transferred to the rollers? The obvious agent was the lubricating oil, which was more than plentiful. It had been remarked that the discolorations on the rubber were more often dark green than brilliant green; this, it was imagined, would depend on the quality of the oil which was forced out upon the rollers by the unequal rotation of the ends of the rollers in the bushes. Fresh oil would give a lighter stain than oil mixed with all the dirty matter which collects in the machines.

What the grease contained.

A sample of this conglomeration was taken from the machines, near the bushes, and was examined in the laboratory. It was found to be a most heterogeneous mass, containing oil,

dirt of all kinds, pieces of bark, tacky rubber, and was of a dark green colour. Portions were tested while moist and traces of copper were evident.

Portions of the greasy mass were spread on paper by means of a spatula, and gritty particles could be felt quite distinctly. Careful scrutiny revealed the presence of several bright particles of brass, and with the aid of a magnifying-glass they were seen to be numerous.

In the course of the work carried on in this laboratory it is curious to note very often that a case such as this remains singular only for a very short time. Before a month had elapsed another and yet another case was reported.

In the last example there were more green patches than green streaks, and it was very confirmatory of our previous explanation to find that tiny particles of brass could be discerned in the rubber even without the aid of a magnifying-glass. There appeared to be no traces of contamination by oil, so that it would appear as if the particles of brass from the bushes had been projected by the uneven motion of the roller-ends and had fallen into the trays beneath the rollers, being there taken up by the rubber.

There can be no doubt that the whole matter can be traced back to the worn condition of the bushes of the machines; but one is tempted to ask why the particular defect in the rubber should only appear now, whereas brass bushes have been in common use for years. Can it possibly be, as some argue, that the machinery now supplied to estates is inferior in quality to the machines supplied in the past by the same makers? Or is it to be ascribed to the fact that machines which have been in constant use for years are now beginning to show the effects of hard work? It was suggested in one quarter that possibly the defect arose from neglect on the part of those responsible for the running of the machines. Undoubtedly the rollers with which colourless coagulum has to be worked into pale crêpe should receive constant attention, when one takes into consideration all the possible little blemishes which may be incident.

COTTON-WASTE.

Mention has not been made before in these pages to this very frequent complaint of brokers, because it was thought the remedy and explanation lay in the hands of managers. Recently cases have been brought to notice in which any explanation of the occurrence of cotton-waste seemed impossible. For instance, how explain the presence of cotton-fibre in smoked sheet? Yet

one broker's report made the complaint. Again, the only possible explanation for the presence of cotton-fibre in No. 1 quality crêpe rubber would be that the cotton-waste used by the person responsible for the running of the engines and machines had been left upon the top of the machine and had inadvertently been put into the rolls. Yet we are assured in some cases that this is impossible. Some machines are lubricated by grease-caps, in which case there would be no need to bring cotton-waste near the machine.

In the case of the lower grades of crêpe rubber there is a very feasible explanation. In one or two factories it has been noticed that engine-drivers are not too particular as to what becomes of the used cotton-waste. A handful which has done service sometimes remains where it falls, and if it happens to be near a heap of scrap rubber it is easy to imagine that it might go into the machine.

One other possible explanation is that stray pieces of coolies' clothes come in with the scrap rubber; or that fibres may remain in the cups on those estates which have their cups cleaned with cloths.

In case it may be a perpetual source of wonderment to managers that a complaint of the presence of fibre in smoked sheet was made, it may be explained that on examination fibre was certainly present on one surface; but the position and nature of it gave an immediate indication of its origin. The estate in question was only producing smoked-sheet on a small scale, and in place of the usual wooden supports small ropes were used, the fibres of which adhered to the surface of the rubber. Such a fault was easily remedied; but in other cases where the higher grades of crêpe are reported as containing cotton-fibre the solution of the mystery rests with those in charge of the factory processes, and calls for more stringent investigation than has been accorded in the past.

Within the past few months particular attention has been given to this subject, and the writer, in the course of visiting factories, has made a point of looking for possible explanations. It has been observed that the fault chiefly occurs in the lower grades of scrap rubber. In some instances the amount of cotton-fibre present in large pieces is appalling, and could not be accounted for by the accidental inclusion of a piece of coolie cloth. Examined microscopically, there was no doubt that the fibre consisted of cotton. The fact that such large quantities

were present in low-grade scrap rubbers seemed to point that the fault occurred in the factory. In spite of assurances that coolies were not allowed to use cotton-waste for cleaning the machines, it was proved that in many instances the assertion was not strictly true. In all probability coolies were not allowed the use of cotton-waste, but the fact remained that they did, as was evident on close investigation. In a few instances lumps of cotton-waste were seen on machines; in others they were found sodden with water beneath the machines, and generally, cotton-waste in large quantities was to be found in the outer drains. Unless there is a European assistant in constant charge of the store, it is recognised that the management has a particularly difficult task to see that orders and rules are strictly obeyed; but it is certain that most of the mischief arising from cotton-waste is due to the gross negligence and disobedience of the factory coolies. In the case of cotton-waste found in drains, it is easy to see that some of it must be brought in with the scrap rubber cleared from the screens. This would account for its presence in such large quantities in the lowest grade of scrap rubber. That the quantity is not inconsiderable may be gathered from the fact that in a twelve feet length of crêpe there was sufficient waste to form a small handful.

The appearance of cotton-waste in high-grade crêpes must be most unusual, and the writer has not yet seen a case in a drying house. That it does occur, however, seems to be evident from brokers' reports. It is extremely difficult to imagine how the waste enters the rubber. One possible explanation is that a coolie may have been cleaning the rolls surreptitiously with waste, which may have passed later into the rolls together with rubber. Another explanation was offered in one factory by the observed fact that coolies engaged in cutting up coagulum, ready for passing into the machines, kept a wad of waste for the purpose of keeping the knife-blade clean. This waste was seen upon the table only when the manager was not present. The writer later called the attention of the manager to the fact, and it was then found that one of the coolies had some cotton-waste concealed in his waist-cloth. It must be recorded, however, that although an exhaustive examination was made of the dry and drying rubber then in the store, no trace of contamination by cotton-waste in the higher grades of crêpe was found, although its presence was detected in one or two lengths of earth-rubber scrap crêpe.

Bark.

With ordinary machines and the usual process of working, it would seem impossible to wash and macerate some of the scrap rubbers sufficiently to free them entirely from bark. This applies specially to the grade of rubber prepared from bark shavings. Specimens have been handled in which it was practically impossible to detect bark, but in such instances the amount of working necessary would be such as to interfere seriously with the regular working of the factory. Even with the employment of a "Universal Washer" complaints of the presence of bark in dry crêpe have been received, but it is certain that this mode of operation reduces the quantity of bark to a minimum. While fully realising that the amount of working it is possible to give in proportion to the existing machinery and the output per day is limited, it must be recognised that the working of lower grades of rubber is usually insufficient, and that where possible it is the duty of estates to pay more attention to these lower grades. A considerable improvement in this direction has been noticed during the last twelve months. There is certainly something in the argument that it would be rather superfluous to go to extreme trouble in the preparation of low-grade rubber when the market seems content with the present output, and is apparently not willing to pay more. There is the added consideration, also, that manufacturers using low-grade plantation rubbers have an installation of machines in which such rubbers are thoroughly re-washed before use. Whether such consumers would be willing to pay more for a cleaner low-grade rubber, or whether they would prefer to buy the present article and re-wash it to their own satisfaction, is a point on which the writer is not qualified to adjudicate at present. Information from the manufacturers is required, and it is hoped that it will be forthcoming in due course.

The incidence of bark in higher grades of crêpe may be due to unavoidable circumstances or to negligence. In the former class one might put those occasions on which pieces of bark are embedded in lumps of naturally coagulated rubber. A piece of bark shaving may fall unnoticed into latex and be partially responsible for the coagulation which takes place. This piece of coagulated lump may be massed with others, and hence, unless each small piece is cut up, the bark is not perceived. Or again, by some unknown means a piece of shaving may drop into a jar of latex, and so become embedded in the coagulum. Sometimes this becomes evident on cutting up the rubber, but it is quite

as likely to pass unseen. On the whole the presence of bark in first-grade rubber is most unusual, and should be seen before the rubber is packed.

In the class due to negligence may be included cases in which careless coolies place the cup upon the ground before tapping. Pieces of shavings fall into the cup, and coolies are too lazy to pick them out. More often than not coagulation in the cup is caused. As it is impossible for the European staff to supervise each individual tree tapped, some cases must continue to pass unheeded. Sometimes bark shavings are brought in with the latex, and if a broken sieve is being used, these, with other impurities, pass into the jar and are embedded in the coagulated rubber. This must be classified as negligence, for no manager would willingly allow the use of a broken sieve. Again, naturally coagulated lump rubber on arrival at the factory sometimes contains evident pieces of bark, leaves, and stems of leaves. For lack of supervision the average coolie would not think of picking out these obvious impurities, and would pass the whole mass into the machines.

Oxidation streaks.

Since the introduction of sodium bisulphite defects due to streaks caused by portions of the coagulum becoming oxidised have practically ceased to exist. In the usual course, and without the use of an antiseptic agent, the freshly coagulated rubber has a surface darkened by oxidation. Unless this dark surface were carefully cut off there would result a crêpe containing dark streaks caused by the mixture of the oxidised surface portion with the bulk of the paler coagulum. The presence of oxidation streaks in crêpes now being made would imply either that no antiseptic substance was in use or that the quantity was insufficient. In the case of sodium bisulphite the quantity necessary to prevent this surface oxidation is exceedingly small (see Chapter VII). Although the price obtained would appear to be influenced by the presence of oxidation streaks, no evidence can be obtained that the actual quality of the rubber suffers to the same degree as does the appearance.

"Yellow-latex" streaks.

This appearance of "yellow-latex" streaks is not common, and may be accounted for by incomplete mixture of two different latices. It is a fact of common observation that when a new portion of bark is being tapped for the first time there is a distinct yellow tinge in the latex excluded. As tapping progresses this colour vanishes; usually it may persist for a period varying from two weeks to more than a month. Should this

latex be poured into ordinary latex without thorough mixing it is sometimes found that, when the crêpe rubber is dry, there are distinct yellow streaks. It should be remembered that as the rubber content of the latex from first tappings is high, this latex is lighter than latex which is more dilute, so that the mixed latices must be well stirred with a broad paddle to obtain intimate mixture. It would be much better to keep yellow latex apart and coagulate it separately.

Bisulphite streaks. These, again, arise from defective mixing. In the dry rubber it is seen that there are streaks of colourless rubber in a general mass which may be of varying shades of yellow; or, to put it another way, a length of exceedingly pale rubber is apparently streaked in patches with a darker shade of colour. A solution of sodium bisulphite is heavier than latex, and there would be a tendency, therefore, for the chemical to sink in the large mixing jar. Unless stirring is thorough it is possible that portions of the latex would not be in contact with sodium bisulphite while others receive more than a fair share. Especially would this effect be seen where coagulation takes place quickly, and experience bears out the truth of the suggestion. Another factor which has some bearing on the point is the strength of solution in which sodium bisulphite is used. In the ordinary course of working the acid coagulant is added immediately after sodium bisulphite has been stirred in. Should a strong solution of the bisulphite be used, and if coagulation takes place quickly, it is easy to see that the possibilities of obtaining a uniform and intimate mixture are small. Probably in no factory is the sodium bisulphite now added to latex in powder form, but it has been found by the writer that if care is not taken to see that all the bisulphite has dissolved before the solution is added to latex, streaks may result in the dry rubber. The undissolved particles sink to the bottom of the coagulating jar or tank and there slowly dissolve, forming local strong solutions. The effect upon the rubber in the vicinity of these strong solutions is much more marked than in the bulk of the coagulum, and hence lighter streaks or patches appear in the dry rubber. In spite of apparently complete mixture by good stirring, it will be seen that it is possible, therefore, to have failed in this direction if any undissolved powder remains in the solution of sodium bisulphite.

"Spot" diseases. Of all the work with which this laboratory has had to deal during the past three years, it is probable that the incidence of "spot" diseases was fraught with the greatest consequences.

It is quite possible that the extent to which the diseases might have spread and the anxiety which they caused have not been fully realised. At the present time, thanks to the results of investigations made by this laboratory, there are practically no cases, and if the guidance given in the writer's periodical reports is followed, there need be no fear of further infection.

First noticed at Seremban.

It was in May, 1911, that the first case of crêpe rubber being affected by some organism which caused pink spots was brought to my notice in the Seremban district. No reminder need be given that at that time the whole of the peninsula was feeling the effects of an extraordinary drought, which could not be paralleled in the records of the previous twenty-six years. Two months previously an investigator in North Borneo had reported the appearance of "spotted rubber" there.

The sample submitted to the chemist was of a most peculiar appearance, the rubber being apparently sprinkled with ruby-coloured spots. Almost simultaneously cases were reported near Kuala Lumpur and Port Dickson, while the chemist's own samples were in one case affected by pink-coloured spots.

It was suggested that this pink colour was caused by one of the most common of bacteria, *Bacillus prodigiosus*. This bacterium (*B. prodigiosus*) is not peculiar to tropical countries, and has been observed for several centuries. It has been shown to be the original "Wunder-blut" of the Middle Ages, and as stated in Report No. 7, is the cause of "blood-rain" and other phenomena. It seems to make a sudden appearance at irregular intervals and then disappears. It is chronicled as having appeared at Padua in 1819, affecting especially cooked foods, in blood-red specks. The attack lasted just one week. In 1848 there was a similar epidemic in Berlin. It seemed to appear especially during hot summer months. Each red spot is a little colony of bacteria, and the growth of *B. prodigiosus* is easily distinguished by the red colour which the organism excretes.

Was it, or was it not, *B. prodigiosus?*

On examination, this was found to be the case, and it is indisputable that a culture of this bacillus was obtained. Meanwhile, however, investigations upon other samples of affected rubber failed to reveal the presence of *B. prodigiosus* and showed the existence of a fungus. At that time a very reliable bacteriologist denied the presence of *B. prodigiosus;* in every case submitted he succeeded in obtaining only a fungus.

A few weeks later, however, he did succeed in identifying the bacterium, thus confirming our previous work.

Singularly enough, the number of cases of diseased rubber affected by *B. prodigiosus* diminished rapidly as the drought gradually became less marked, and as soon as the rainfall became normal no further cases were reported.

Fungoid-spot disease wide-spread.

On the other hand, the number of cases of rubber affected by fungoid-spot increased at a tremendous rate, until that estate could count itself providentially fortunate which did not have to report that its rubber was diseased.

Much anxiety, and no little alarm, was felt until we were able to show from tests that in spite of the effect caused by the disease upon the appearance of the rubber, the quality of the rubber upon vulcanisation was not affected. While this was a consideration which went far to allay anxiety, there remained the problems as to how the disease arose, how it was spread, and how it might be prevented.

How did it arise?

Taking matters in their proper sequence now, we have to consider first how the disease arose; but at the time of the outbreak the first question in every manager's query was as to how the disease could be cured if possible, or how it might be prevented. It can be pointed out that really the prime point of importance was as to how the disease arose. If that were known, the second consideration as to how it was spread would follow easily, and we should be well on the way to a solution of the third question.

At the same time, this laboratory does not exist for pure research work, and it was felt that the usual method of procedure should be reversed, *i.e.* that the question of prevention or cure should receive first consideration. If success were attained by practical methods, the other two problems would receive attention in passing, and their final solution might wait upon practical results. Fortunately, by going direct to the question of prevention, reliable guidance was soon obtained. The second problem, as to how the disease is spread, has been practically settled, but as to the direct origin of the disease, or why it made such a sudden and wide-spread appearance, very little is known, and that little is speculative only.

In the course of the writer's investigations it was found that the outbreak of May, 1911, did not mark the first appearance of the disease in the Peninsula. Some four years previous the disease had been noted on the estate which was the first to report the outbreak of 1911, and it is doubtful whether we should have had any information of this fact but for an accidental

discovery. As far as we know the case was not reported at the time. The means of investigation were then inadequate, and so what might have been nipped in the bud was passed unheeded.

It is probable that the minute fungi continued to flourish in a moderate degree until the exceptionally prolonged drought of 1911 brought with it the actual conditions necessary to the fungus for a more vigorous and widespread existence. The succeeding rains, in all probability, were materially helpful to the life and spread of the fungus; it is certain now that the presence of moisture is beneficial to the growth of the fungus in its present form, although it does not follow that the existing form is identical with that probably assumed during the long drought.

Here we are on more familiar ground, and, without wishing to be too technical, we can say that the disease extends its scope by means of very minute spores, as in the case of another well-known plantation disease, viz. "Diplodia rapax." These spores are invisible to the naked eye, and so even the layman will appreciate the difficulty of placing any check upon the disease in the field. Under the microscope, however, it is seen that there are many forms of fungi, each of which apparently excretes a characteristic colour. These colours are known to most planters and are evidenced in crêpe attacked by fungoid disease. The most common colours at present are orange, reddish brown, black, and yellow. At least, those are the colours visible to the naked eye; under the microscope they are modified somewhat in the case of the apparent black and reddish-brown colours. How is the disease spread?

In all cases, microscopic examination betrays the existence of fungi in one or another form, and the appearance of these forms is highly interesting.

It is now practically certain that most of the infection may be traced to the latex becoming infected in the field. As the spores are so very minute, it would be impossible for the planter to say that the latex was or was not affected; apparently, however, the fungus in the rubber needs about five to seven days before it shows its presence by the excretory colouring matter in the ordinary course of events, but cases have been known in which coloured spots begin to show after three or four days. It is generally found, however, that there have been special circumstances which were favourable to the development of the

fungi. It was noted in several instances that factories hitherto free from disease suddenly reported the appearance of coloured spots. The history of the infected rubber was investigated, and it was found in all of these special cases that, through mishap to the engine or the incidence of a holiday, the coagulated rubber had been standing in bulk of a day or so. Again, it was remarked in several cases that the freshly-prepared crêpe had been folded and allowed to stand over night before hanging. In one or two instances the rubber which had been so folded showed coloured spots, while that which was hung immediately was free from disease. Obviously, therefore, in these cases the slightest condition which made for retention of much moisture was the factor governing the appearance or non-appearance of the disease.

In the earlier stage of the investigations it was considered necessary to advise the isolation of all affected pieces of rubber, as it was not definitely known to what extent, if any, infection could be transferred by air-borne spores from an infected to a normal piece of rubber. Although it is now practically certain that infection takes place almost entirely in the field, there is no cause to regret that isolation was recommended. Lacking definite information, which could only be obtained as the result of many months' work, it was a measure dictated by common-sense, and one which would be again resorted to in the event of the incidence of a disease similarly obscure and unknown. It is now fairly certain that, although it is possible for the disease to be spread by close contact of two pieces of rubber, infection does not take place by spores being air-borne from infected pieces of rubber in the drying houses to healthy rubber. Experimental work has failed to record any instance in which infection has been obtained in that particular way; and even though infection can be effected by contact, it has been shown that in the majority of cases contact must be very close and in the presence of much moisture.

Another point which seems to be fairly established is that dry rubber cannot be infected even by contact with an infected piece of dry rubber. There have been one or two instances noted which would apparently form exceptions to this conclusion, but closer investigation shows that there were other factors in control.

An interesting case was submitted in which a length of crêpe had been folded. The upper portion was in contact with the

lid of the case, and by the time the rubber reached home it was badly affected by the brick-red fungoid disease. The lower portion, although belonging to the same length of crêpe, and actually in contact with the diseased portion, shows no sign of disease. When the folded piece of rubber was opened out the boundary between the diseased and healthy portions was the mark of the fold. An opinion was advanced that the colour of the upper portion might have been caused by contact with the lid of the packing case which, we understand, had been made locally. Unfortunately such a simple explanation does not fit the facts, which are that—

(*a*) This brick-red colour had in other instances been an indication of fungoid disease.

(*b*) Samples showing this characteristic colour had been found in drying-stores, without ever having been in contact with a packing case.

(*c*) A microscopic examination revealed the presence of a fungus.

These facts do not altogether rule out the possibility that the wood of the chest, if in a slightly damp condition, was infected with the fungus. We know that the presence of moisture encourages the growth of this micro-organism, and it is easy to imagine that a top layer of crêpe might easily become damp during transport. Here, then, we have the probable explanation of this case.

Other possible conditions might be that some of the rubber was infected when packed. The spores from this rubber would then only attack the damp piece of rubber. Or it might be that the piece of crêpe was not quite dry when packed; but this is only a very remote possibility in the case of thin crêpe, and, at all events, if the rubber was still moist when packed we should have expected the lower portion to be affected also.

In any case, however, it would be wiser not to pack any diseased rubber with sound rubber. Cases have been known in which, by some easily possible means, the whole or part of the contents of a box became damp, and it is not to be doubted that disease present in some pieces of crêpe was thus communicated to other perfectly healthy pieces.

A point not yet satisfactorily settled is as to how far infection may be caused from contact of wet rubber with timber. One investigator has put it on record that infection was proved to have been due to the fungi in rough jungle poles which were

used for suspending the rubber. A culture of the fungi in the timber was obtained and proved to be identical with that in the rubber. Experiments in this laboratory have failed to find any confirmation of this observation, so that there can be no definite conclusions to put forward at present. However, even presuming it may be shown later that there is no need to fear infection from timber in the drying sheds, it might be beneficial to adopt some measures for disinfecting the houses.

Probably the simplest method is that of washing or spraying all woodwork with formalin. A 5 per cent. solution may be used; but the effect is not of long duration.

Potassium permanganate solution has been recommended, but this would not be a very good suggestion owing to the possibility of some of the liquid falling upon rubber. Not only would it be likely to discolour the rubber, but it would have an injurious effect on the rubber in the course of vulcanisation processes.

Could the drying-house be well closed up a good method would be to burn sulphur in the drying-house for twenty-four hours at the rate of about 2 lbs. per 1000 cubic feet of space. Previous to the burning of the sulphur all woodwork should be made thoroughly wet to favour the formation of sulphurous acid.

From the fact that the possible resting places for spores are more numerous, and further that the fungi are capable of living, maturing, and germinating in the wood of the walls or racks when moist, it follows that the chances of infection are vastly greater in a wooden drying shed than in one constructed of iron and wood.

It cannot be insisted upon too much that the continuous presence of moisture is one of the factors favourable to the spread of infection; and for that reason it is necessary that all factories and drying sheds should be in open spaces of fair extent, and not, as in some cases, absolutely surrounded by trees. It will do no harm also to repeat that one type of factory is a direct source of encouragement to the spread of disease. This refers to that type of so-called "economical" factory in which the drying-room, with an open floor, is situated directly above the coagulating and machinery room. The floor of the latter is usually awash with water during the day-time, and even at night the air must be near saturation point with moisture. One may be almost positive that any drying of the

rubber in this type of house only takes place during the day-time when the sun is shining upon it. At night the air is usually so moist that large drops of moisture condense upon interior walls; and it is almost impossible to conceive how the rubber can be expected to dry.

The direct connection between the rate of drying and the incidence of coloured spots in crêpe rubber has now been so firmly established that it is a source of amazement to all thinking people that thick crêpe continued to be made on estates where spot disease was rife. Samples continued to reach the laboratory, some thick, and others "thin-thick" through having been finished on a diamond-pattern cut roller. In the latter cases there is a distinct pattern of intersecting ribs which vary from twice to three times the thickness of the intermediate diamond-shaped portions of rubber. There is the obvious fact that, always, the coloured spots are to be found on these thicker ribs of the pattern. Why; and why not on the intermediate portions? Simply because the rib pattern, being much thicker than the remainder of the rubber, was the last to dry out, and gave the fungus time to reach that stage in its life when it excretes colour. Surely this is an elementary deduction which should appeal to all, and which should convince one that, where crêpe is to be made in a district liable to fungoid-spot disease, only thin crêpe should be made; and that it should be finished only on a smooth roller.

From experimental work carried out in this laboratory it is now known that, even if the latex has become infected with fungus spores, it is possible by the use of antiseptic agents such as formalin to prevent the appearance of coloured spots in the drying rubber.

In conclusion the chief points may be summarised as follows:—

1. No coagulum should be left without working for longer than the ordinary period. Otherwise, the prevailing conditions are very favourable for the development of the disease.
2. Thin crêpe only should be made. The quicker the rate of drying the less possibility is there of the coloured spots appearing.
3. Crêpe should never be allowed to remain folded over night. It should be hung to dry as soon as possible.
4. Several varieties of fungi and bacteria causing coloured

spots have been recognised, and it has been proved conclusively that it is possible to infect latex and also fresh coagulum.

5. As far as our present knowledge goes, it appears that infection takes place chiefly, if not entirely, by means of the latex in the field-cups. It may take place during transport also, or even during coagulation.
6. While it is certain that infection can be caused by contact, it has not yet been shown that infection of the finished wet rubber takes place in the drying houses by means of air-borne spores; at least, under ordinary drying conditions.
7. There is reason to believe that no further infection takes place once the rubber is well into the drying stage, and that dry rubber is not infected even by contact. From this one might infer that, as long as rubber remains dry, infection cannot take place during the voyage to England.
8. Coloured spots do not appear until the rubber is half dry, because that period is necessary for the development of the fungus to that stage in its life history when it excretes colouring matter. The fungus in its earlier and colourless stage may have been present from the time the latex entered the cup.
9. The natural habitat of the fungi would appear to be decaying vegetable matter in the field.
10. Finally, if it is found impossible to be rid of fungoid-spot disease after having exercised all care and observed all known precautions, nothing remains but to supersede the ordinary drying process by some system of quick drying, such as the vacuum-drying process or a hot-air draught system, in which the rubber dries so quickly that any possibility of appearance of "spots" is entirely removed.

As we have before indicated, the best means of avoiding "spot" disease is acceleration of drying. For this reason, and should the demand for crêpe rubber be sustained, one should be prepared to see the introduction of artificial dryers to a much greater degree in this country. With their use there can be no danger of infection, and the rubber could be handled very much more quickly; but, on the other hand, we have the fact that nearly all samples from Malaya, prepared in artificial dryers,

have shown on testing a slight inferiority to naturally air-dried crêpe rubber. Furthermore, there is a very important consideration, namely, that with the employment of nearly all artificial dryers it is impossible to turn out thin crêpe. The thin crêpe originally made has to be re-rolled, owing to its sticky condition, between wet rolls into thicker crêpe, and then air-dried.

TACKINESS IN RUBBER.

Tackiness is an old enemy of every manager. With modern ideas of erection of factories to guard against the introduction of direct sunlight, it was hoped that this defect had practically ceased to exist. In one grade of rubber it would be expected that tackiness would continue to appear. Earth rubber, often exposed to direct sunlight for a week, would naturally become tacky, and this tackiness cannot be avoided unless the earth scrap is to be collected more frequently. But in the recent cases even the higher grades of rubber show signs of tackiness. Experiments have been carried out at various times and in various places to determine the cause of tackiness. For some time the theory of bacterial origin was in favour, but none of the experimental results were convincing. Bacteria may be present in tacky rubber; but, on the other hand, many cases of bacteria in rubber have been observed in which there was no tackiness. Experiments have been made in this laboratory with a view to testing the bacterial theory by inoculating latex with small pieces of tacky rubber. In opposition to the results which Bamber is stated to have obtained there was no spread of tackiness. Other investigators have obtained similar results. One writer proposed to explain tackiness as caused by excess of moisture. This perfectly simple explanation unfortunately displays only a profound ignorance of the subject, and does not take into account the fact that tackiness is incident in rubber after dryness has been reached. It need not be pointed out to planters in Malaya that wet sheets of rubber are often exposed to direct sunlight by workers of native holdings, with no resulting harm as long as plenty of moisture is present in the rubber.

Tackiness the result of a slow process of change.

As stated above, tackiness does not appear until the rubber is dry, and, even then it is to be noted that it is possible for tackiness to appear in rubber arriving in London, which showed no indications of tackiness when packed for shipment.

Tackiness caused by traces of copper salts.

Spence, as the result of investigations, points out that none of the various theories put forward to account for tackiness, viz. the action of bacteria, premature putrefaction, oxidation, excess

of moisture, the action of enzymes, etc., have any basis in scientific proof, and believes that the cause of tackiness cannot be directly attributed to bacteria. It was stated in a recent book that the only known way of causing rubber to become tacky is to expose it to sunlight or heat. While agreeing that in the ordinary way this statement is correct as far as one rules out the employment of chemical substances, it must be pointed out that tackiness of the worst degree may be caused by the presence of traces of copper or copper salts. This fact is well known to some planters, on account of a rather costly experience which befell one manager. It is advisable, therefore, that no vessels or tanks used in a factory should be made of copper, if possible.

Tackiness generally and almost universally due to the action of direct sunshine or heat.

With the exception of the foregoing cause of tackiness we know of no others than direct sunshine or artificial heat. One would be quite correct in stating that almost without exception tackiness may be attributed to one or the other of these two causes. In the face of all other theories the fact remains that tackiness can always be produced by placing rubber in the direct rays of the sun or near some other source of heat. Sometimes the proof comes unsolicited and causes trouble which might have been avoided easily by seeing that no openings are left in the walls or doors of the drying-room. In one case under observation tackiness was observed to be forming in a strip of rubber which hung behind a closed door. It was found that an extremely narrow slit between two planks allowed admission of direct sunshine for a few hours each day. Naturally the affected portion was extremely narrow and appeared as a streak down the middle of the strip. In course of time the tackiness developed to such an extent as to travel through the thickness of crêpe to the other side of the strip, and later on the strip divided by its own weight longitudinally along the weak tacky streak.

Is tackiness spread by contact?

Regarding the question as to whether tackiness can be communicated by contact opinion is divided. One writer states that sound rubber left in contact with tacky rubber was found to be unaffected after two years. On the other hand, another is stated to have obtained tackiness by infecting rubber by means of small tacky pieces. Unfortunately there is some difficulty in deciding this point owing to the fact that in the ordinary way one cannot be sure that the apparently sound rubber has not been exposed to heat or sunlight, and that tackiness would not

have appeared eventually in any case. This, of course, applies to shipments of rubber from estates. As far as our own investigations go we cannot say at present definitely that tackiness is or is not spread by contact; but the presence of a sticky substance transferred from the tacky piece to the sound portion placed in contact with it is quite sufficient to prejudice the value of the sound rubber. Hence there should be the utmost care used in excluding any suspicion of tackiness from packages of otherwise sound rubber. All tacky pieces should be packed and shipped separately.

No cure for tackiness.

At the present state of our knowledge there appears to be no cure for tackiness. Neither do we see the necessity for a cure when the phenomenon may be avoided by taking simple precautions, which may be briefly summarised thus—

(1) Any openings through which it is possible for direct sunlight to enter, whether large or small, should either be totally closed or provided with some substance which cuts off the direct effect of the sunlight, *e.g.*, ruby glass or ruby glazed cloth.

(2) Rubber should under no circumstances be placed near any source of heat.

(3) No rubber should be hung in a drying-room in such a position adjacent to a door that it is possible for sunshine to reach it by accident.

(4) Instruments or vessels of copper should not be used where acids are employed.

In the course of experiments made in the laboratory tackiness has often been induced by the use of traces of copper salts. The rate at which tackiness is induced appears to be dependent upon the amount of copper salt used, but once it begins the rubber molecule is very rapidly broken down and resins are formed. As the formation of resins is accompanied by the inclusion of oxygen in the chemical constitution it would be expected that dry rubber becoming tacky should increase in weight. This is found to be the case, and to give an idea of how this weight increases with the progress of tackiness, the results below may be studied.

Sample.	Amount of copper salt.	Weight of rubber.				
		When dry.	After interval of 4 wks.	Further interval of 7 wks.	Further interval of 3 wks.	Percentage increase in weight.
		Gms.	Gms.	Gms.	Gms.	
1	0·02 gms. copper sulphate, per 100 ccs. latex.	430	441	482	488	13·5
2	Ditto	428	439	481	486	13·55
3	0·01 gms. copper sulphate; 0·01 gms. copper acetate — per 100 c.cs. latex.	962	987	1035	1036	7·7
4	0·025 gms. copper sulphate, per 100 c.cs. latex.	502	513	558	560	11·5

It will be seen that the maximum quantity of copper sulphate used amounted to 0·025 per cent. (approx.) upon the weight of latex taken. Now it is highly probable that only a fraction of this quantity was retained in the rubber on coagulation, the remainder being in solution in the serum. Furthermore, as the rubber was well washed and worked down to thin crêpe, the total quantity of copper salt remaining in the dry crêpe must have been exceedingly small. Yet the effect is most marked and should impress upon all managers the necessity for guarding against any possible contamination by brass or copper.

Lack of uniformity in colour.

This is the charge most commonly made against shipments of rubber from plantations, and the complaint will continue to be made as long as latices from separate fields of varying age continue to be coagulated separately. It is an easy matter to recognise the difficulty, but it is not so easy to find a practical remedy. Undoubtedly, even if the latex from a whole estate were bulked and coagulated, there would continue to be slight variations between the outputs of some days. Rain may fall, and the latex may be more dilute. Droughts occur, and the latex may be very rich in rubber. To suggest that these variations do not occur in Fine Hard Para is the height of absurdity. It is true that, owing to the nature of the curing process, the variation in colour is not so evident, especially as one day's rubber is superimposed upon that of another, but nevertheless there is the same general variation which is beyond the control of the individual.

At present, however, when figures of yields and costs have to be kept for each field or division, variation in colour must

occur, as no two latices are identical. The utmost that one can do is to bulk all latex each day from one division, regulating the quantities of acid and sodium bisulphite according to the dilution of the latex. It has already been pointed out that dilute latices (within certain limits of dilution) require less acid and less sodium bisulphite to effect coagulation and produce the same colour than do richer latices. Yet it is common to find that the same quantities are used irrespective of the age of the trees and the rubber content of the latex. As a consequence it is usually found that the rubber from young fields is paler than rubber from older fields, and this variation will continue until more strict attention is given to this question of dilution and quantities.

Air-bubbles in block rubber.

One of the recent complaints made against block rubber is that of the inclusion of air-bubbles. As block rubber is built up from crêpe, it was suggested that the air-bubbles were primarily in the crêpe. This suggestion is rather wide of the mark, as any one acquainted with crêpe preparation would recognise. What is probably the best explanation is that the crêpe prepared for block-making was of very rough texture and may have been full of holes. When layers of such rubber were placed one upon the other and submitted to great pressure it is natural to suppose that air would be contained in the holes, and would be unable to escape. To guard against this it would seem necessary to prepare the crêpe thin and with a fairly good surface finish.

It must be obvious to all acquainted with the processes involved in the preparation of block rubber that no possibility exists for the presence of air-bells in thin crêpe. When the vacuum-dried crêpe is folded preparatory to the blocking process it is apparent that between the layers there must always be a considerable volume of air, a small proportion of which is bound to be retained owing to the nature of the surface of crêpe rubber.

That this has always been true of the preparation of block rubber cannot be denied. It is possible, of course, for one type of block to show the presence of air-bells more than another type, the proportion of air enclosed in blocking depending naturally upon the nature of the crêpe of which the block is composed. A block built up of layers of smooth, fine crêpe would be expected to contain less air-bells than a block composed of layers of a rough crêpe.

But where the mode of preparation of crêpe on an estate has

remained uniform over a number of years it is extremely difficult to imagine that the number of air-bubbles in that estate's block rubber can have shown any marked augmentation.

Block rubber has been seen which was free from air-bells, but this was the thin variety of block prepared for show purposes with far greater care, probably, than would be possible in commercial preparation.

It has now been shown, we hope, that an exaggerated importance has been attached to the presence of air-bells in block rubber, and that their occurrence should not detract in any way from the value of the rubber. At the same time we recognise that the buyer naturally calls attention to any little apparent defect. It is his business to obtain his goods at the cheapest price, and we should be surprised if there were not some little complaint to be made.

CHAPTER XV

DEFECTS IN SHEET RUBBER

It has been pointed out that the incidence of mould growths on unsmoked sheet may be regarded as a natural process, and that their absence may be looked upon as somewhat singular. It has been found that sheet from dilute latex and well rolled is not so liable to moulds, and that sheets from rich latex, or not sufficiently rolled to express contained moisture, are subject to extraordinary growths. Even when the rubber is dry, moulds continue to grow in moist air, and no amount of brushing or washing will get rid of them. Moulds.

Attempts have been made to prevent mould formation by the use of chemicals. At one time it looked as if the brushing of sheets with an emulsion of creosote would be successful; but the effect was not lasting, and the rubber was covered with mould by the time it reached home. Strong formalin has been tried with no permanent effect. On some estates at the present time the sheets are washed in a weak solution of permanganate of potash, and the method is reported to be successful. The general use of this substance is not to be recommended, as a trace of the permanganate in rubber has a decidedly harmful effect upon vulcanisation. If, however, the sheets are thoroughly washed, there is a little possibility of any permanganate remaining.

Dipping the sheets into a solution of copper sulphate was recommended some years ago with disastrous results. All the sheets so treated became tacky before they could be packed, and it makes one wonder what the mass looked like when the boxes were opened.

Moulds on smoked sheet sometimes are reported, but it must be thoroughly understood that in these cases the effect must have been due to an insufficiency of smoke-curing. It sometimes happens that the smoking accommodation on an estate is not sufficient to allow of the retention of the rubber from the wet to

the final dry stage. It is put into the smoke-house for a few days and then air-dried. Or it is first partially air-dried and then smoke-cured for a few days. Under these circumstances it is not surprising that the rubber is reported as arriving in a mouldy condition. Even the actual period of total drying is not always sufficient, and whenever possible the rubber should be allowed to remain in the smoke-house for some days over and above the time taken to dry.

Uneven appearance of sheets.

A batch of sheet rubber is sometimes reported as being uneven. Presumably this refers to size and colour, and in such cases the effect may be traced to the fact that unequal quantities of latex are poured into the dishes; or that comparison is being made between rubber from old and young latices. In the latter the sheet would be thinner and lighter in colour, and it would dry more quickly. As nearly as possible the same quantity of latex should be placed in each dish, with the proviso that in the case of dilute latex more will be necessary to produce a sheet of average size. It is not thoroughly appreciated that this question of thickness of sheet has such a great effect upon the final colour and appearance of the rubber. Yet it should be obvious that the thinner the sheet the lighter the colour when viewed by transmitted light. Similarly the longer a sheet remains in the smoke-house the darker the colour obtained. If a sheet is thin it dries quickly, and if it be taken out when drying is completed the sheet will be correspondingly light in colour. Of two sheets, one thick and the other thin, smoke-cured for the same length of time, that which is thicker will appear to be darker in colour. Hence, care is necessary in regulating the quantity of latex to be put into dishes and in arranging that a uniform period of smoking be allowed.

Oxidation of air-dried sheet.

It has already been pointed out that, failing the employment of substances such as formalin and sodium bisulphite, oxidation in air-dried rubber is a natural process; and that it can only be prevented by resorting to special manipulation, such as steeping in hot water, etc. From the buyer's point of view it would appear desirable to obtain air-dried sheet free from oxidation, and therefore the plantations must resort to artificial means of producing the required article. If sodium bisulphite is to be used, a caution must be given that only the absolute minimun (to be found by trial) necessary to prevent surface oxidation must be used, otherwise the drying may be somewhat prolonged.

Some estates have thought it necessary to prevent surface

oxidation on sheets which were to be smoke-cured. Varying quantities of sodium bisulphite and formalin have been used and the general result has been that the sheets when dry are very light in colour. It is a moot point whether the market requires pale smoked sheet or not. Apparently many brokers do not realise that the paleness of the sheet is no criterion of the curing period, and pale sheets which have been very fully smoked for three weeks have been rejected as being "under-smoked." Reference to this point will be made in a later paragraph. In the meantime it may be stated that in the opinion of the writer it is not necessary to prevent surface oxidation in rubber which is to be smoke-cured. Oxidation of smoked sheet.

That "spot" disease may appear in air-dried sheets was painfully evident at the beginning of the outbreak in the spring of 1911. The first cases noticed took the form of pink and bluish "blushes" spreading over the whole of the sheets. These effects were shown to be due to bacteria, but later fungoid spots began to appear. These mainly took the form of red or black blotches and were very unsightly. As "spot" disease cannot develop in smoked rubber, the obvious and simple course to adopt was to smoke-cure the sheets. When it is stated that "spots" do not develop in smoke-cured rubber it is understood that the smoke-curing must be efficient and must commence as soon as the rubber has been rolled and the surface water has drained away. If the sheets are allowed to air-dry for a few days the disease may develop, and then smoke-curing will not get rid of the coloured patches. The operation of smoke-curing may tone the colour down, but the spots would still remain evident. "Spot" disease in sheet rubber.

Why any estate, large or small, should persist in making unsmoked sheet is beyond understanding. It must be plain that, besides the freedom for "spot" diseases, the simplicity of the process, the quickness of drying, the freedom from mould outgrowths and the consequent saving in labour, there are the outstanding and indisputable facts that a better price is obtained, and that the physical qualities of the rubber are improved. In spite of the simplicity of the operation of smoke-curing complaints are made by brokers on several grounds. As a rule, the defects arise in the operations which precede smoke-curing, but some are to be traced to the smoking alone. Smoked sheet.

A twelvemonth ago some one on the market made the discovery that smoked sheets were arriving at home with "virgin VIRGIN SPOTS AND AIR-BUBBLES.

spots" in them. Immediately the rest of the experts took up the complaint and much mystification was caused on the plantations. After some little time it was understood that sheet rubber was supposed to have arrived full of small patches of moisture. An examination of several rejected samples was made and the writer was able to show that the so-called "virgin spots" did not consist of moisture but were due to the inclusion of air-bubbles, which, when cut across, gave a lighter colour than that of the mass of rubber. Viewed by transmitted light they were opaque, and hence arose the erroneous idea of moisture being present.

Air-bubbles and not "virgin" spots, in smoked sheet.

The original complaints of "virgin spots" would seem to indicate a vast ignorance of the methods employed in the preparation of this grade of rubber, inasmuch as it seemed to be the idea of some that these pale patches or spots were due to "insufficient drying of the rubber before smoking." It need hardly be pointed out, of course, that sheets for smoke-curing are not air-dried previously, but are put into the smoke-house about three or four hours after rolling. The rubber remains in the house until perfectly dry; in point of fact it is generally allowed to remain in the smoke for quite a week or more after dryness is attained, for the purpose of still further improving the quality of the rubber. That such improvement does result is now an established fact.

It may be accepted, therefore, that no estate withdraws its sheet rubber from the smoke-house before it is dry. What then are these "virgin" spots which the complaints indicate? If the spots are cut through with a sharp knife it will be found, on close examination, that the pale colour is not due to the presence of moisture but to the presence of smaller or larger air-bubbles enclosed in a film of rubber. Sometimes a patch is composed of hundreds of minute air-bells, each surrounded by a very thin film of rubber. On holding the sheet up to the light and stretching it across the pale patch it is often possible to distinguish each bubble distinctly. In such cases the patch appears to be colourless; but on allowing the rubber to retract the pale colour is again visible by reflected light. It must have been observed that thin films of rubber, no matter what the colour of the mass may be, are very pale in colour—in fact, almost colourless. Wherever, therefore, we have a mass of small air-bubbles enclosed in the rubber we have apparently a pale spot which might be mistaken, by the novice, for a moist

patch. It does not, however, need much discrimination to distinguish the one from the other.

If an affected sheet be examined carefully it will be found that the longer axis of the spot often lies in the direction of the length of the sheet. This at once supplies a possible explanation, connected with the pouring of the latex into the dish.

With these introductory remarks we enter now upon a consideration of the possible causes of the enclosure of these air-bells or bubbles. One significant fact must be appreciated, namely, that the number of cases has increased during the last year. That is to say, the number of cases has increased in proportion to the decrease of the quantity of water placed in the cups in the field. As estates one by one decrease this added water to a minimum consistent with safe working, so the trouble with air-bubbles increases.

Causes of the formation of air-bells.

But let none hasten to say that because of this we must revert to the old customs. It will be shown that remedy is much more simple and less dangerous than that.

STRENGTH OF ACID SOLUTION.

The question involves another consideration, and a much more important consideration than most people are likely to credit until they prove it in practice. It is that of the strength of acid solution employed in coagulation. In the old days, *i.e.* about three years ago, it was the rule rather than the exception to find pure undiluted acid used in coagulation. In many cases no harm resulted, for the simple reason that owing to the large proportion of water in the latex the acid was thereby much diluted. Only in one or two non-progressive estates does that custom still hold, and in every case they have to thank the over-dilution of the latex for the non-injury of the resulting rubber.

This argument applies also to the cases where estates still use a comparatively strong solution: *e.g.*, 1 part acid to 5 parts water. Most estates make up the stock solution of 1 part acid to 20 of water, and use this with success because of the fair amount of added water present in the latex.

Proportions of stock solution, as well as quantity used, must be considered.

It must be understood that what is being referred to now is not the absolute *quantity* necessary for coagulation, but the *proportions*, i.e. *the respective volumes of acid and water in the solution of acid made up every day*. That the strength of the acid solution, as well as the quantity used, has an effect upon coagulation can be easily demonstrated in the following way:—

Take separate and equal lots of the same latex, and to each add the same *quantity* of pure acid but in each case diluted with varying quantities of water. It will be found that coagulation is quickest where pure acid is employed and slowest where the acid is most dilute. It will also be found that, providing the quantity of acid employed was sufficient for coagulation, the best and most uniform coagulation is obtained from the use of dilute acid, and it will be found often that where pure acid has been used coagulation is neither uniform nor complete, and that the remaining serum may be slightly milky. There would seem to be an idea amongst managers that acetic acid is only effective in solutions of the order of 5 per cent. and upward. There cannot be a more mistaken notion. If the latex as brought into the factory is fairly pure it will be found possible to use a 1 per cent. solution of acid. Frequently even this is found to be too strong in laboratory work and a half per cent. solution is used. It stands clearly then that even if the actual quantity of acid used is correct, coagulation may be hastened and rendered less complete by the use of strong solutions. It follows also that the quicker the coagulation the more air-bubbles are enclosed.

Another frequent cause of the inclusion of air-bubbles may be deduced in the following way. If latex be allowed to coagulate naturally (*i.e.* without addition of acid) in a glass vessel, it will be observed that the coagulum is a spongy mass full of gas-bubbles. If separate samples of latex be taken, to each of which an increasing quantity of acid be added up to the quantity necessary for complete coagulation, it will be found that the number of gas-bubbles and the sponginess of the coagulum decrease with the amount of acid added. It would seem evident, therefore, that if latex is allowed to coagulate naturally fermentative processes are engendered which result in the formation of acid and gases. To such an extent does this take place that the coagulum is often found to be much swollen by the pressure of gas. It is justifiable to assume that in a lesser degree this is what happens if rich latex has to stand too long before coagulation can be effected. During this interval its acidity has been increasing, and less acid coagulant, therefore, would be required to be added. When, however, the ordinary quantity is added coagulation is rapid and any bubbles of gas are enclosed. The remedy would appear to lie in the arrangement that latex should be quite fresh when coagulated, and that if too rich it may be diluted with water.

The first cases of air-bubbles in sheets were not difficult to solve. It was noticed that the air-bubbles took the form, in the whole sheet, of a fan. Obviously the explanation was that either strong acid had been added to each dish with instant coagulation, or that the acid was placed in the bottom of the dish and latex poured upon it with extremely rapid coagulation.

It is found, therefore, that enclosed air-bubbles or gas-bubbles in sheet rubber may be ascribed to one or more of the following causes:—

(1) The use of an extremely rich latex. In this case it would be advisable to dilute the latex on arrival at the factory with a quantity of water ranging from one-half to an equal volume.

(2) Allowing latex to stand too long before coagulation: putrefactive processes are incident causing liberation of gases. That this is so may be shown by allowing latex to coagulate naturally over-night in a tall glass vessel. The mass of rubber is found to be quite spongy, and is seen to be honeycombed in all directions.

(3) The most prolific cause of air-bubbles is probably the use of over-strong solutions of acetic acid. The days when pure acid, even in correct quantity, was used in coagulation are gone; though we still find a few estates persisting in using solutions as strong as 50 per cent. This is in distinct contrast with the strengths of solutions used on progressive estates, where the acid is diluted to solutions varying from 5 per cent. down to 0·5 per cent. Unless the quantity of acid necessary for complete coagulation is well diluted an intimate mixture of acid and latex cannot be effected; coagulation is apt to be local and extremely rapid where strong solutions of acid are used, with the result that bubbles of air or gas are unable to escape from the solidifying mass.

(4) To the placing of acid solution in the bottom of the dish and the act of pouring in latex upon this acid.

(5) To the addition of acid to the latex in each dish and to the insufficient and irregular stirring which almost inevitably follows.

Support marks.

It frequently occurs that one sees across the middle of smoked sheets a wide mark. This is where the wooden support in the smoking-chamber has been. As a rule even in the most

careful cases a faint mark may always be seen, but in many instances this mark is exaggerated to such an extent as to point to lack of care on the part of the store supervision. If bays of racks remain empty over-night they may possibly become covered with a light sprinkling of fine wood-ash, if the floor screens are not sufficiently small in mesh. Wet rubber placed upon these racks will pick up and retain the impurities, and more often than not they cannot be washed out. It is incumbent upon the manager to see that empty racks are thoroughly cleaned before placing wet rubber upon them. At the same time the opening below each bay of racks should be closed by fine-mesh gauze in order to guard against the rising of ash and soot.

OVER-SMOKED SHEET.

Apparently the market believes it is able to judge whether a sheet has been over-smoked or not by its appearance. There could not be a more mistaken notion. Granted that the sheet has only been smoke dried, it is impossible to judge by any surface appearance. It would be extremely interesting to know what the brokers and buyers take to be indications of over-smoking. As far as can be gathered they are an extremely dark colour and a very shiny appearance. Neither of these conditions can be accepted as a reliable guide to over-smoking. The depth of colour may be due to heavy oxidation and the thickness of the sheet. A surface shine may be due to the employment, as fuel, of substances rich in creosote or tar, and this surface deposit may become marked before the rubber is really dry.

It may be a new aspect of the case to most readers, but the writer is of the opinion that the darkening of sheet rubber in the process of smoke-curing is not so much due to absorption of constituents of smoke as to the rapid oxidation which may take place at such temperatures. In support of this theory it might be pointed out that if sodium bisulphite or formalin be used to prevent this oxidation, the rubber may be smoked for weeks without a very great effect upon the colour. So much is this so that smoked sheet prepared in this fashion and cured for more than three weeks was reported upon by brokers as being under-smoked, whereas ordinary sheet cured for the same period was classed as over-smoked. It would appear that the question of over-smoking is decided chiefly by the surface appearance of the rubber, and hence it is necessary to guard against the use of rich fuels such as cocoa-nut husks alone, mangrove timber alone, or tarry substances. The use of the last-mentioned materials is not to be recommended at any time, and cocoa-nut husks or

"bakau" timber should only be used in conjunction with the ordinary dead timber to be found on estates.

Apart from this question of appearance, it is probably true that there can be no real "over-smoking" of sheet rubber in the practical working of a factory. As a matter of fact, it has been shown that with extended periods of smoke-curing there is an improvement in the quality of the rubber. This subject will be dealt with more fully in Chapter XVIII.

"Under-smoking."

There may be two grounds for complaint with regard to "under-smoking." The complaint may be due to the paleness of the sheet, which gives rise to the idea that the rubber has been insufficiently smoked. It has been shown in the paragraph on "over-smoking" that the question of colour has little to do with the duration of smoke-cure, and can be influenced at will by preliminary treatment. A pale colour, therefore, is no indication of the degree of smoke-cure. A legitimate complaint may arise from the appearance of moulds upon smoked sheet, and it is certain that in this case the rubber has been insufficiently cured. It should be apparent from these remarks that there can be only one legitimate reason for complaint in the matter of "under-smoking," and that is the incidence of moulds. The other consideration mentioned should be regarded as merely a question of lack of colour.

Resinous appearance.

It is extremely difficult to understand the exact grounds or evidence upon which the complaint of resinous appearance is based. Sometimes, if a sheet be stretched and allowed to contract, there appears on the surface a brownish stain which by some is accepted as evidence of the presence of resins. It can be definitely stated that such is not the case, and that generally the particular appearance alluded to is the outcome of imperfect coagulation. When this takes place fine particles of coagulated but non-coalesced rubber are attached to the surface of the sheet. When the sheet is stretched this film of fine particles is broken up, and hence shows up in a lighter shade than the general colour of the rubber. It is not known whether this is the defect which causes the complaint, or whether there are any real grounds.

It is quite possible, however, that the defect in the sheet rubber was real, but that the expression "very resinous" was the only description which would convey any meaning to the broker himself. Unfortunately, it does not convey anything definite to us. Managers will agree that we are becoming

just a little tired of these complaints, which are so very vague.

A certain amount of resin is necessary.

However, we have been at pains to show that the amount of resin in plantation smoked sheet has no deteriorating influence on the rubber. Not only so, but that the resin is absolutely necessary for the proper vulcanisation of the rubber. It is with a certain amount of pleasure, therefore, that we saw, in a recent number of the *Journal of the Society of Chemical Industry*, an article by another chemist (L. E. Weber) on the action of resin in the vulcanising of rubber. His conclusions confirm our own work. The summarised account of his experiments may be interesting.

"Half a pound of Highland sheet Ceylon rubber * (3·6 per cent. resin) was cut up and extracted with acetone for 15 hrs., after which it still contained 0·3 per cent. of resin.

"Three mixings were made of rubber, litharge, sulphur and whiting, using—

(1) The original rubber.
(2) The extracted rubber.
(3) The original rubber with the resins added from the extract of (2).

"Number (3), therefore, had a double quantity of resin as compared with number one. After vulcanisation in an auto-clave at 120° C., 130° C., and 150° C. respectively, it was found on testing that the maximum strength of (1) and (3) was practically the same, while (2) had not vulcanised. Thus the resins are necessary for vulcanisation, and a high resin content is not necessarily an indication of inferiority."

Further comment is not necessary, and there is no pressing need for managers to employ, or seek to employ, any special methods for attempting to diminish the amount of resin natural in the rubber.

COLOUR.

The question of colour in smoked sheet would appear a very important one to buyers, but unfortunately little guidance is given to the producer. It is common to find that while complaints are made to one estate of the paleness of its rubber, another estate has no difficulty in disposing of as much pale smoked-sheet as it can supply. In other cases it is complained that smoked sheet is too dark, while a neighbouring estate supplying very dark sheet is commended for its product. These differences of taste

* All plantation rubber was known as Ceylon rubber in America until quite recently

are inclined to be rather exasperating at times, and some estates are driven to preparing both pale and dark sheet to meet the fluctuating fancy of the market. Some time ago the writer, in response to what was thought an indication of the wishes of buyers, advised several estates to abandon the preparation of pale smoked sheet in favour of dark sheet. Sheet of medium colour was shipped and received with much favour in certain quarters. In other cases, however, the only result was a complaint that the rubber appeared to be "over-smoked." On the whole it would appear that there is a real demand for sheet rubber which, when viewed by transmitted light, appears in colour to resemble a rich dark syrup, and it would be well perhaps for all estates to aim at this. To obtain it one must not use sodium bisulphite or formalin, and the smoking must be extended a little longer than the actual drying period. That the question of colour has any direct bearing upon the quality of the rubber must be denied. It is easy to show by results that a pale sample may be superior to a dark sample, or even to a sample which has been smoked for a longer period. So much depends upon the attention paid to the preliminary operations. As direct evidence in favour of the above statement the following cases may be studied :—

(1) Pale smoked sheet: treated with sodium bisulphite and smoked for two weeks.

(2) Dark smoked sheet: three weeks smoke-cured.

(3) Dark sheet: ordinary make of the estate, smoked for four weeks.

All the samples came from one factory, and were expressly prepared for the New York Exhibition of 1912.

On vulcanisation the tests gave the following numerical results :—

	(1)	(2)	(3)	Standard.
Resiliency	66·5	67	64	65·5
Resistance to stretching	143	135	135	140
Recovery (sub-permanent)	95·5	94·9	92·2	94·1

It will be seen that the pale sample (No. 1) prepared with sodium bisulphite and smoked for two weeks is superior to both the dark samples and to Standard smoked sheet. The ordinary smoked sheet prepared on the estate is the only one inferior to Standard in spite of the fact that it had been smoked for the longest period and was dark in colour. This difference in the rubbers is due to the fact that special care was taken in the preparation of samples (1) and (2).

The question of colour in smoked sheet, therefore, gives no indication of the value of the rubber unless full details of the mode of preparation are known.

Over-heating and tackiness.

Complaints of over-heating are very rare, and those of tackiness in smoked sheets are rarer still. Yet some have been made, and apparently not without cause. It is extremely difficult to imagine that the temperature of any smoke-house would be allowed, or could be allowed, to rise to such a degree that tackiness would occur. There are only very few smoke-houses in the country probably in which there are no maximum registering thermometers. But if their rubber became over-heated or tacky it would be their own fault entirely. As smoking is, in quite 90 per cent. of factories, only carried on at night there must be some means of knowing the temperature, otherwise the coolie in charge of the fires may continue in his wrong-doing.

Only one case of tackiness has ever been observed by the writer in a smoke-house, and in that instance it was a sheet which had fallen upon the expended metal below a bay of racks. At the same time the tackiness of this solitary sheet was a reliable indication that the temperature of the smoke-house generally was far too high.

In case of over-heating sheets often become soft to the touch, but apparently recover on exposure to the outer air. Where air-bubbles are present in the rubber it becomes quite spongy, and if the surface be nipped between the thumb and fingers miniature balloons are formed which burst with a sharp crack.

Owing to the use of fuels rich in creosote, sheets often become coated with a sticky deposit, and if the sheets are packed in this condition they can only be pulled apart with some little difficulty. This stickiness must not be confounded with tackiness, and may be removed before packing by washing the sheets either in cold or lukewarm water. After this surface washing the sheets may be air-dried for a day or so, and if the smoke-curing has been efficient no apprehension need be felt on the score of moulds.

ESTATE BRANDS OR PRIVATE MARKS.

There has been serious complaint recently that smoked sheet from other estates (not necessarily inferior in quality) has been sold under the name of well-known estates. There would seem to be little doubt that this is the case, and it is natural that the better known estates whose smoked sheet has gained a reputation on the market should feel aggrieved. In the days when plain

sheet was made it was a very easy matter to stamp the name of the estate upon the rubber, but it is not so simple to put a brand upon ribbed sheet. Many suggestions have been made at various times for devices by means of which a private and distinctive mark might be impressed upon ribbed sheet. It was proposed to use a hydraulic, or other power, stamp; and this should prove practicable. But a better idea is to cut the name of the estate and any other mark into the "marking" rolls. This course has been adopted by two companies with success. On one estate the pattern of the sheet is a large diamond mark. In the diamond spaces small letters are cut either longitudinally or in the direction of the circumference of the rolls. If the device be carried in a circular direction it is possible to repeat the private brand a large number of times on the same sheet. As practised on the other estate the name and mark are cut on a strip running around the middle of one roll. In this way the device is repeated down the middle length of the sheet four or five times. There would appear to be some difficulty in making the home engineering firms understand exactly what is required. All that is necessary is that when the rolls are being pattern-cut a strip of metal about three-quarters of an inch should be left untouched on both rolls. On one of the strips the name or mark may then be cut and can be repeated as often as possible. The strip on the other roll may be left plain or may have a very shallow-cut pattern put upon it so as to provide a grip upon the rubber as it passes through the machine. There should be no difficulty in making any number of variations of these methods of marking smoked sheet, and the fact that we are told of engineering difficulties should be very much discounted. The work of cutting a design upon rolls was done by an assistant on one of our estates, and surely it should be an easier matter for mechanics at home to accomplish. Estates wishing to have a distinctive mark, and this should include all, should take up the matter at once.

CHAPTER XVI

COMPARATIVE STRENGTHS

NUMERICAL RESULTS. Explanation of terms.

THE numerical results of the vulcanising tests on manufacturing lines, of the samples of rubber sent home, with which the descriptive reports of those tests are supplemented are reported under the headings Resiliency, Elasticity, and Recovery. A general explanation of the value of these terms is appended.*

"RESILIENCY.—This word may be applied to the rate at which a body returns to its original shape after suffering some form of deformation. Thus, for instance, if an indiarubber ball be allowed to fall to the ground the portion striking the ground becomes flattened, but soon starts to regain its original shape. The faster it does this the greater the impulsive forces imparted to the ball and the higher it bounces. The rate of recovery to its original shape is too rapid in this instance to allow of satisfactory measurement, and for experimental purposes it is necessary to work with our material in a more convenient form than that of an indiarubber ball. In this and the subsequent tests the rubber is conveniently cut to the shape of a strip or ring and is stretched several times in succession. The resulting figures are given in diagrammatic form in the Fourth Report, pages 20 and 22. If a body were perfectly resilient, that is to say, if it were to return to its usual shape *immediately* after compression, we should represent its resiliency by 100 per cent. There is no substance with such properties. Rubber, however, possesses the quality of resiliency to a fairly high degree, as some of the samples approach the figure of 70 per cent. A body without resiliency would be a substance like putty or lead, which are hardly resilient at all. If a putty or lead ball be allowed to fall on a hard, resisting surface it becomes flattened and shows little, if any, tendency to return to its original shape.

"ELASTICITY (Resistance to Stretching).—This is a term which, unfortunately, is used in very different senses by different

* From a report by Messrs. Clayton Beadle & Stevens.

people. Correctly speaking, it is the resistance which a body offers to forces tending to alter its shape or form within the elastic limit. Thus the substance which requires the greatest force to stretch or compress it is the most elastic. In our experiments we determine the resistance offered by a sample to a force tending to stretch it. We take a strip of a definite size and length and find the force necessary to stretch the sample to a definite extent. The figure 100 is chosen empirically for an average quality material. If the resistance is less the figure is smaller, while a material offering no resistance, like a piece of wet clay, would have the figure 0.

"This test also gives us the strength of the rubber when vulcanised—the higher the figure the stronger the rubber.

"Recovery.—When a material is stretched or compressed, and then released, it does not immediately return *fully* to its original shape. There is a more or less permanent 'set,' and, whereas the rate of recovery (resiliency) is very rapid, the recovery from the last traces of distortion is very slow, and there may even be a permanent deformation. If the deformation be measured soon after release it is not permanent, but as the recovery at this stage is slow, it is termed 'sub-permanent.' The recovery (sub-permanent) is measured by stretching the sample five times by application of the same maximum load and measuring the increase in length immediately after release. This is then calculated as a percentage on the increase in length of the rubber when stretched. If the recovery were complete, there being no sub-permanent set, the sample would show a recovery of 100 per cent. If, however, the sample did not recover at all, but remained permanently stretched, as in the case with some such substances as putty or a lead wire, the recovery would be *nil*.

"The Recovery (Admiralty) differs from the preceding in that the stretching is more severe, and is prolonged for twenty-four hours. The measurements are also delayed for six hours after release; the recovery is therefore a more permanent one than the preceding. The test also differs from the former in that the samples are stretched to a given length and not to a given load. Obviously, this test will be less severe on samples which are softer, more easily stretched, and which show a better figure for elasticity. The principle of this test is used largely by buyers and manufacturers, as it is relatively easy to apply in a simple manner; but all these tests are used technically in one form or another."

CRÊPE RUBBER GENERALLY. From experience in handling specimens of all grades of plantation rubber, and as the result of vulcanisation tests on scores of samples, it can be stated broadly that crêpe rubber, of whatever grade, is inferior to rubber prepared in sheet form. This is a definite conclusion on a point which might have been deduced theoretically. No matter what the class of rubber prepared in crêpe form it has to undergo a fair amount of maccration in course of the process. On the other hand, the only force used on sheet rubber is pressure, with the idea of squeezing out as much moisture as possible. There is no severe pulling or tearing, such as rubber undergoes in crêpe preparation. It is an axiom that the more maccration the fresh coagulum has to suffer the weaker the final product; in the parlance of manufacturers the "nerve" of the rubber is affected. We are continually being reminded of this. In spite of these statements from manufacturers, it is curious to note that the finely finished crêpes which have, as a rule, undergone the most severe treatment are those which command the highest prices at the sales. It is known, of course, that the demand for such finely finished rubber does not really emanate directly from the manufacturer. The dealer who buys the rubber, is, however, apparently supplying the demand of the consumer. It would be idle to argue that the manufacturer is not responsible indirectly for the kind of rubber supplied at present, for presumably he would only buy what suited him. Under these circumstances, there can be only two conclusions. Either the manufacturer requires heavily worked crêpes with a good finish at the expense of a loss in strength, or the difference caused by heavy working is so light as not to be appreciable to the manufacturer. If the latter is the case, then there is no necessity to warn estates against heavy working. On the former ground, again, the responsibility rests upon the consumer and not the producer. If planters were asked to give an opinion as to the strengths of different grades of crêpes, it is probable that the majority would place scrap rubbers in the highest position, with a preponderating favour towards naturally coagulated lump. As a rule, this opinion would be fairly correct, and is borne out by the tests.

Fine-pale crêpe. Leaving out of consideration earth-scrap crêpes, most planters would be of the opinion that fine pale crêpe was the least worthy from a stand-point of physical qualities. This idea has been obtained in the first place from direct knowledge of all the processes of preparing fine pale crêpe. In spite of this knowledge

gained by experience and the information obtained from experimental work, it is rather disconcerting at times to find planters deluded with the idea that a thick gristly crêpe made up from fine pale crêpe is ever so much stronger than the original thin crêpe. It is so easy to be deceived by appearance and hand tests, in spite of the evidence given in Chapter IX., that as a rule thick crêpe made from thin is inferior on vulcanisation to the original thin crêpe. This effect can only be ascribed to the extra maceration necessary in building up the rubber to the thick form. If, as we are told, manufacturers prefer this thick crêpe then we can only assume that the rubber is judged and valued on appearance pure and simple. That such would appear to be the case is fairly certain since we are told by brokers that the thick gristly thick-from-thin crêpe "looks like rubber." It is not to be wondered at, therefore, that planters are perplexed. On the one hand, they are told that fine crêpes should receive the least possible working, as over-maceration tends to weaken the "nerve" of the rubber. On the other hand, they see that the product which commands the better price is that rubber which has undergone the most working. Under such circumstances, and in view of the fact that the planter wishes to sell his rubber to the best advantage for his company, who can blame managers for shutting their eyes to the proven scientific facts and making what will sell best on the market? Every planter will agree that he should only make the best of rubber, but what is the best, and who is to decide what is the best? In our present stage of knowledge all that one can conclude is that the best is what commands the highest price for the time being, and as long as manufacturers hold such varied opinions on the subject there is very little hope that any approach will be made towards standardisation of output. Especially is this so under the existing arrangement of buying and selling which apparently, while giving a supposed guide to the demand, is really a delusion. On the whole, therefore, with regard to the value of fine pale crêpe, the planter stands in the unhappy position of having to reconcile his knowledge with the selling price of the rubber.

Naturally coagulated lump rubber.

All the arguments in the foregoing paragraph apply with even more force to the crêpe prepared from naturally coagulated lump rubber. From the planter's point of view this is an excellent rubber. Any objection to the use of acid is entirely met in lump rubber. To put the matter in a planter's way of looking at it, the rubber consists of the richest part of the latex

much as cream is the richest portion of milk. It is lifted out of latex, which must be correspondingly weak in rubber content. It undergoes as a rule much less working, and at any rate should be at least equal to pale crêpe in physical qualities. It has the defect that the lumps in transport to the factory often oxidise quickly on the surface, so that the final dry crêpe has not a bright appearance, and is streaked with more or less dark patches. Judged on appearance it obtains a lower price than its quality merits. This is all the more singular in view of the statement of manufacturers that colour in the original crêpe does not matter as the colour of the final vulcanised article is entirely influenced by the ingredients used in mixing. The fact remains, however, that crêpe prepared from naturally-coagulated lump rubber obtains a lower price than fine pale crêpe because of its appearance, and one is unable to see any possibility of the position being otherwise.

Lower grades of crêpe.

In considering the market situation with regard to lower grades of scrap rubber the planter is fairly in agreement with the manufacturer. It is undoubtedly true that in the past too little attention was given to the washing and general preparation of the lower grades of plantation rubber. This may not be ascribed to indifference but to the facts that in such a young industry attention was specially given to the higher grades, and that the high prices obtained a few years ago for any low grade rubber happened to be so high. With a general fall in the price of rubber managers began to find that a little extra care in the preparation of low-grade rubbers resulted in an increased sale price. Manufacturers correctly refused to pay for bark and other impurities in the weight of rubber, especially as it necessitated heavy re-washing before it could be satisfactorily used. At the same time, given a clean rubber, there is no reason why an earth-scrap crêpe should not be every whit as physically strong as fine pale crêpe; provided that the rubber had not been allowed to remain on or in the ground too long. Here again presuming a clean rubber, the question of appearance is against the rubber and influences the price. In a number of instances it has been found that rubber prepared from the lowest grade, *i.e.* earth-scrap, has proved to be superior on vulcanisation to the fine pale crêpe from the same estate. It must be confessed, however, that in the past at least the majority of earth-scrap rubbers would not have shown up so well, and that even at the present time a very large number would be classed as weak

owing to the fact that the scrap has been allowed to be exposed too long before working. This accounts for the observed fact that tackiness is more common in earth-scrap rubbers than in any of the other grades. The number of cases in which insufficient attention is paid to the lower grades of rubber is continually on the decrease, and the margin between the prices of the high and low grades of rubber is correspondingly diminishing. There are sufficient grounds for hoping, therefore, that the quality of low-grade crêpes will receive adequate consideration.

UN-SMOKED SHEET.

Concerning the strengths of average air-dried sheet, it can be said to occupy an intermediate position between smoked sheet and pale crêpe. Thus, if a quantity of latex were to be divided into three portions, one of which provided pale crêpe, another air-dried sheet, and the third smoked sheet, the physical qualities would be in an ascending order from pale crêpe. And of two sheets from the same batch, one air-dried and the other smoke-cured, that which is air-dried is always inferior to that smoke-cured. This fact alone, without taking into account freedom from moulds, the difference in drying periods, and the difference in market price, should be sufficient to convince any one that the preparation of air-dried sheet is a waste of time, labour, and money. It would even be better to make pale crêpe than air-dried sheet, if one had the machinery already installed. In this way there would be a great saving in time of drying, a great deal of mould trouble would be avoided, the working of the factory would be more pleasant, and it is probable that the price obtained would not be less.

SMOKED SHEET.

There can now be none who does not acknowledge the superiority of smoke-cured sheet over every other form of plantation rubber from the point of intrinsic value. The fact that the price of smoked sheet sometimes falls below that of pale crêpe does not alter the truth of the statement, as no reliance can be placed on fluctuations in market prices. It can be accepted as a fact that in smoke-cured sheet plantations offer their best product. There are occasions on which a smoked sheet from one estate may prove inferior to a good crêpe from another estate, and in such a case the result may be ascribed to lack of care in the preparation of the sheet rubber. On the whole, however, the attention now given to the preparation of smoke-cured sheet rubber has placed it in a position to compete directly with Fine Hard Para in physical qualities, and it would not be making too rash a statement to say that many of our

estates are preparing smoke-cured rubber which is superior to Fine Hard Para. Numerous instances have been given during the past three years of the superiority of smoked sheet over other grades of plantation rubber. To repeat the mass of figures here would take too much space and be rather monotonous. It will be quite sufficient to state that as a result of this experimental work standards have been set up for smoke-cured sheet and pale crêpe. These standards are high, and in testing all samples are placed in comparison with one or the other.

The actual figures are :—

	Standard smoked sheet.	Standard pale crêpe.
Resiliency . . .	65·5	58·5
Resistance to stretching .	140·0	124·0
Recovery (sub-permanent)	94·1	90·8

And from these figures the usual disparity between the two grades are made plain. The fact that it is possible to improve the quality of rubber to a wonderful degree by smoke-curing may be seen from the following instances :—

1. Standard pale crêpe.
2. A sample of pale crêpe.
3. A sample of lump rubber crêpe.
4. A sample of tree-scrap crêpe.
5. An ordinary smoked sheet.
6. Smoked lump-rubber crêpe.
7. Smoked tree-scrap crêpe.
8. An excellent smoke-cured sheet.
9. Standard smoked sheet.
10. Fine hard para.

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
1 . .	58·5	124·0	90·8
2 . .	59·5	117·8	90·0
3 . .	60·2	121·5	92·0
4 . .	63·3	136·6	90·0
5 . .	65·5	149·0	93·5
6 . .	68·5	141·2	95·3
7 . .	67·3	130·2	93·8
8 . .	73·9	158·3	97·7
9 . .	65·5	140·0	94·1
10 . .	61·5	120·0	91·2

In this mixed batch of samples it will be noted that we have an earth-scrap crêpe and a tree-scrap crêpe which, by smoke curing, have been improved beyond the quality of either Standard smoked sheet or Fine Hard Para. We have also an excellent sample of smoked sheet, which is so much superior to any other sample as to place it in a class by itself. Yet there was nothing mysterious in its preparation. It was one of an ordinary batch, made with care, and smoke-cured for one month.

Leaving aside the results obtained in our experimental work we are able to turn for confirmation to the results of vulcanisation tests upon samples submitted to the London Exhibition of 1911. These tests were carried out by manufacturers. Sixty-two samples were tested in all, and an interesting group of figures was obtained, which showed the relative intrinsic values of the different grades.

The mode of calculation is the addition of all marks obtained by each sample of any one grade, and the division of this total by the number of entries of that grade of rubber. The marks refer only to the vulcanisation tests, to which 70 marks were allotted out of the 100 given for the three classes of tests. With a maximum, therefore, of 70 marks the results work out as follows:—

	Average marks.
Nine samples; smoked sheet obtained	66·6
Seven ,, smoked crêpe ,, ...	60·4
Five ,, darkish ,, ...	59·0
Thirteen samples; pale sheet	56·5
Three ,, ,, biscuit	55·0
Twenty-five samples; pale crêpe	53·2

We have no information as to what the darkish crêpes were. They may have been smoked or not. Comment on the foregoing results would be almost superfluous, but it might be pointed out that *the difference between the average marks obtained for smoked sheet and the marks for the next sample is greater than the difference between any other two grades.*

With 70 marks as a maximum, and the average marks of each class calculated as a percentage of the maximum, the list would appear as below:

	Percentage average marks.
Smoked sheets	95·1 per cent.
Smoked crêpes	86·3 ,,
Dark crêpes	84·3 ,,
Pale sheets	80·7 ,,
Pale biscuits	78·6 ,,
Pale crêpes	76·0 ,,

Between air-dried sheets and smoked sheets there is a difference of roughly 14·5 per cent. in physical qualities, while between air-dried pale crêpes and smoked crêpes the difference favours the latter by 10·3 per cent.

It will be borne in mind that we had nothing whatever to do with these tests or results, and that manufacturers alone are responsible. Nevertheless, it will be seen that they most thoroughly confirm all that has been written from this laboratory regarding the superiority of smoked sheet over any other grade.

Smoked sheet supreme.

An impressive point is that the samples which headed the list were the smoked samples, and below are given the individual marks obtained by the ten samples which headed the list of vulcanisation marks. They are as follows:—

Grade.	Marks (Maximum 70).	
1. Smoked sheet	70	(Sungei Kapar.)
2. ,, ...	69	
3. ,, ...	69	
4. ,, ...	69	
5. ,, ...	68	
6. Smoked crêpe	65	
7. Smoked sheet	65	
8. ,, ...	65	
9. Smoked crêpe	65	
10. ,, ...	65	

N.B.—The lowest figure obtained for smoked sheet was 60.
,, ,, ,, ,, crêpe ,, 50.

Pale sheet, crêpe and biscuit varied from 45 to 65, but only one sample of each obtained 65 marks.

As bearing on the same question of the relative strengths of plantation grades, the results given below of tests upon a batch of smoked samples should be interesting:—

1. Smoked crêpe: best quality (1) thick.
2. ,, ,, : ,, (2) thin.
3. ,, ,, : from naturally coagulated lump; not quite dry.
4. ,, sheet: poor appearance, thin: from dilute latex.
5. ,, ,, : (1) poor appearance } from one estate.
6. ,, ,, : (2) medium appearance } from one estate.
7. ,, ,, : (3) pale, fine colour } from one estate.
8. ,, ,, : ribbed pattern } from one estate.
9. ,, ,, : diamond pattern } from one estate.
10. ,, ,, : ordinary ,, } from one estate.

11. Smoked sheet: lime-treated peaty water in cups.
12. „ „ : ordinary, smoked one month.
13. Standard smoked sheet.

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).	
1 .	62·0	138·0	89·3	crêpes.
2 .	62·0	134·0	88·6	
3 .	65·5	147·0	93·7	
4 .	56·5	117·0	86·9	sheets.
5 .	65·5	143·0	92·9	
6 .	69·5	160·0	94·7	
7 .	65·5	149·0	93·5	
8 .	70·0	146·0	96·5	
9 .	71·5	152·0	96·2	
10 .	64·5	133·0	90·9	
11 .	67·9	137·2	95·9	
12 .	73·9	158·3	97·7	
13 .	65·5	140·0	94·1	

An examination of these figures reveals the fact that one of the smoked crêpes was superior to standard smoked sheet. In the sheet class there was one exceedingly poor sample, and it would be quite difficult to imagine what the real cause of this inferiority could be. The sheet was certainly a very poor specimen, even when judged on appearance. Of the nine samples of smoked sheet, however, only two are below the standard and the other seven are well above.

No samples tested in the exhibition batch were known to be of grades lower than No. 1, but the dark crêpes which showed up well may or may not have been smoke-cured. In this uncertainty we have no actual guide for comparison of lower grades of crêpe with the higher, in the foregoing set of figures. This deficiency can be supplied from our experimental work.

The following samples were prepared on one estate for purposes of comparison:—

1. First quality crêpe: not a good colour.
2. "Cup-washing" crêpe: poor colour.
3. Crêpe from naturally coagulated lump.
4. Earth-rubber crêpe: slight tacky on mixing rolls.
5. Standard pale crêpe.

NUMERICAL RESULTS.

	1.	2.	3.	4.	5.
Resiliency . . .	59·5	63·4	60·2	63·9	58·5
Resistance to stretching .	117·8	136·6	121·5	136·7	124·0
Recovery (sub-permanent)	89·2	90·0	92·0	91·7	90·8

The outstanding points to be noted in the above results are:—

1. The poorest specimen and the only one inferior to standard pale crêpe is the first quality crêpe No. 1.
2. In spite of the fact that it worked a little tacky on the mixing-rolls, the best sample is No. 4—the earth-scrap rubber.
3. This was followed by the "cup-washings" crêpe No. 2.

Another batch of samples was prepared on another estate, as follows:—

1. Thin pale crêpe. Trees 5 to 12 years old.
2. Pale crêpe: somewhat thicker and darker.
3. Dark crêpe: prepared from lump and tree-scrap: contained a quantity of bark.
4. Earth-rubber crêpe: also contained bark.
5. Standard pale crêpe.

NUMERICAL RESULTS.

	1.	2.	3.	4.	5.
Resiliency . . .	58·6	57·6	59·8	57·8	58·5
Resistance to stretching .	111·4	118·2	112·7	119·9	124·0
Recovery (sub-permanent)	85·8	89·3	88·8	88·0	90·8

These rubbers evidently had not been well prepared, and as a whole are not a good batch, not one of them being up to standard. From a study of the figures we see that:—

1. The poorest specimen is the thin, pale crêpe.
2. There is nothing to choose between any of the other samples.

Lastly, in order to show that the heavy working of fine, pale crêpe must have a damaging effect upon the rubber, and that the value of smoke-curing is not to be under-estimated, the following samples were sent from an estate.

1. No. 1 crêpe: prepared with minimum of working
2. Naturally coagulated lump rubber crêpe
3. Tree-scrap crêpe.

All smoke-cured for 27 days.

4. Standard smoked sheet.

NUMERICAL RESULTS.

	No. 1 crêpe.	Coagulated lump.	Tree-scrap.	Standard sheet.
Resiliency	69·3	68·5	67·3	65·5
Resistance to stretching .	143·5	141·2	130·2	140·0
Recovery (sub-permanent)	94·3	95·3	93·8	94·1

It will be seen that:—

(*a*) Of the three crêpes that made from tree-scrap is the most inferior, but even so it is of quite good quality.

(*b*) There is practically nothing to choose between the quality of the No. 1 crêpe and that made from coagulated lump. As a rule the latter is quite as clean as No. 1 crêpe, and hence in this case it should have commanded the same price as did the No. 1 latex crêpe.

(*c*) Both the No. 1 crêpe and the coagulated-lump crêpe are superior to the standard smoked *sheet*. Undoubtedly smoke-curing was responsible for the vast improvement in quality of the crêpes, but still it is very unusual for even smoked crêpes to equal smoked sheet. Let it not be understood, however, that these smoked crêpes are superior to the smoked sheet from the same estate. In the present instance they were compared with what is known as "standard smoked sheet": a very good sample indeed, but obtained by blending sheets from various estates. As a matter of fact the smoked sheet from this particular estate always gives results which are much superior to those shown by standard smoked sheet. At the same time it is a remarkable fact that the smoked crêpes from this estate always show very high results—in many cases much above those given by smoked sheets from other estates; and this in spite of the extra working to which the rubber must be subjected. The only secrets involved are (1) the use of almost pure latex; (2) the employment of every possible care in the field and factory.

From a study of the foregoing results and many others it would be possible to place the different grades of crêpe in their relative intrinsic values. These, however, would not agree with the real market values of the grades, because the lower grades are not so clean and would lose a larger percentage on washing. Again, most first-grade crêpe rubber is used without washing by the manufacturer, whereas all lower grades are

re-washed (*i.e.* re-crêped) before use. This re-working and the subsequent loss in weight should make a difference of about 2*d*. in the price of the lower grades as compared with the fine grades. On the whole, it may be said that in actual value of physical qualities the lower grades of crêpe are equal, if not superior, to fine crêpe. They suffer in comparison only by—

(1) Appearance.

(2) The need for re-washing; a need which is gradually disappearing.

(3) The loss in weight on re-washing.

It is very evident that buyers are beginning to appreciate the value of the lower grades of crêpe, and the difference in price between fine crêpes and lower grades is a diminishing one. In course of time, as managers continue to give attention to the preparation of lower grade crêpes, the margin should become very small, and the question of colour should be of little importance. The contemplation of such a prospect makes one wonder whether, at some time in the future, it will be worth while going to the trouble and expense of preparing first-grade rubbers. It is suggested in more than one quarter that by saving the cost of collecting latex, transporting it, straining it, coagulating it, and the expense of running this organisation, it would pay to allow all latex to coagulate naturally either on the tree or in the cups. That, however, is a rather far-reaching anticipation which does not seem likely to be fulfilled.

PART V

GENERAL

CHAPTER XVII

PALE CRÊPE *VERSUS* SMOKED SHEET

SMOKED SHEET *versus* PALE CRÊPE AS A MARKET COMMODITY.

DURING the last twelve months there has been a steady demand for pale crêpes, and several estates on which smoked sheet has been very successfully prepared for a long time have been compelled to change their staple product to pale crêpe. It is, of course, no light matter to be instructed to change the whole method of manufacture. The change cannot be successfully carried out in a day, a week, or a month. Coolies learn the routine of one mode of manufacture, and it is hard to bring them up to high-water mark in another method within a short time. Then, again, cases have been known in which a manager has been instructed to make pale crêpe and at the same time lacked on air-drying shed, while the number of instances in which the air-drying accommodation was deficient or unsuitable for making pale crêpe was quite large. Visiting estates, the writer has continually been advised of the instructions from the secretaries to change the staple product, and he has inevitably been asked what he thought about it. It is not very agreeable, perhaps, to hold opinions or beliefs contrary to the nature of one's instructions, and to have to carry those instructions out, but such are common cases. The research work carried on during the past few years has shown that of all plantation grades of rubber, by far the most superior in physical qualities is smoked rubber. This point has been proved so often that one is almost tired of reiterating it. Naturally, therefore, our sympathy goes out to those who appreciate this truth and yet have to supply the demand of the market for pale crêpe. It cannot be denied also that the preparation of large quantities of pale crêpe is a matter of much more worry, and depends more upon chance than the making of smoked sheet, if ordinary

methods alone be employed. In a previous chapter the typical methods adopted on estates for the production of pale crêpes were outlined. It may be stated here that it is natural for freshly coagulated rubber to darken in colour on exposure to air, and if pale rubber must be prepared, special precautions must be observed and various means adopted. So that it is obvious that the production of pale crêpes is fraught with many difficulties. The writer's attention, however, has been directed to another most important point in connection with this vexed question.

The whole gist of the matter may be put in the following question:—

"Supposing that the prices of smoked sheet and pale crêpe were equal at any given date, upon which grade (supposing both grades were sent from the same estate) would the greater profit be made?"

We know that opinions differ upon the question, but what we need now are not opinions but facts in the shape of actual figures of cost.

Two managers have gone into the question very thoroughly, and figures obtained will be reproduced here.

Estate I

Initial outlay.

(A) Let us commence by considering first the stock argument against sheet-making. One is always pointed out the initial outlay necessary for dishes. Seeing that no estate begins to produce in any other form than sheet, it follows that this cost is common to all whether they eventually continue to make sheet or crêpe, and hence this consideration may be swept aside. It might also be borne in mind that as the dishes last for years, the capital expenditure when spread over the hundreds of pounds of rubber made in them diminishes to a mere fraction.

Drying space.

(B) The next point to take is that of drying space. On this estate it was found that the relative drying spaces occupied by equal weights of sheet and crêpe were:—

Sheet.		Crêpe.
5	:	9

Period of drying.

(C) The relative lengths of time taken by smoked sheet and pale crêpe (medium) to dry were of the order:—

Smoked sheet.		Crepe (medium).
10	:	16

(D) The combination of these two results, relative drying space and relative period of drying, gives what is termed here the size (accommodation) factor.

Factor for size of drying store.

(*a*) Presuming that an air-drying house and a smoke-house were of the same size, since sheet only takes 10 days to dry while medium crêpe takes 16 days, it follows that the smoke-house would turn out during any period $\frac{16}{10}$ (or $1\frac{3}{5}$) times the amount of rubber that the air-drying house would yield.

(*b*) Again, if the two houses were of equal size the smoke-house would contain $\frac{9}{5}$ (or $1\frac{4}{5}$) times as much smoked sheet as could be accommodated of crêpe.

Combining these two figures we have the fact that given two houses of equal size, during any given period the smoke-house would output against the crêpe drying-house in the proportion—

$$16 \times 9 : 10 \times 5$$
$$154 : 50$$

i.e. slightly more than 3 : 1.

Putting this in another way, we see that the size of the smoke-house necessary to turn out the same weight of rubber as an air-drying house, would only need to be about one-third that of the air-drying store. This naturally means a large saving of expense.

(E) Coming now to the question of packing, it was found that the relative spaces occupied in packed boxes were :—

Packing space, boxes and freight.

Sheet.		Crêpe.
10	:	14

It follows, therefore, that the number of boxes required for crêpe would be $1\frac{2}{5}$ times the number required for the same weight of sheet.

The freight also would be $1\frac{2}{5}$ times as much since freight is to be calculated on cubic capacity.

(F) On the general run of estate work it has been found that one coolie can make in any period 3 times as much weight of sheet as of crêpe. There are, however, other considerations entering into this question, regarding which we shall be glad to receive information. The question is, what are the relative costs of the actual making of crêpe and sheet?

(G) One very important point, touched upon in previous reports, is that given two equal quantities of uniform latex, one

An absolute loss on crêpe.

of which is made into sheet and the other into crêpe, when the rubber is weighed dry it is found that the sheet always weighs at least 1 per cent. heavier than crêpe, *i.e.* for every 100 lbs. of crêpe obtained one gets 101 lbs. of sheet. This means, at present prices, a distinct loss of about 5*s.* 4*d.* on every 100 lbs. of pale crêpe sold.

This very important point is now receiving close attention both in Malaya and in Ceylon. Managers have been very keen in appreciating the point, but it is to be regretted that more of them did not take the small trouble of obtaining actual proofs. After all, a manager with plenty of latex available, and a practical equipment, has a better opportunity for investigating this point than we have on a small scale in the laboratory. Experiments made by one manager gave the following results:—

(*a*) 20 gallons of latex gave 25¼ lbs. of dry sheet; and 1 hour 25 minutes was spent in rolling, machining, handling, etc.

(*b*) 20 gallons of latex gave 24½ lbs. of dry crêpe: and 1 hour 40 minutes was spent in machining, handling, etc.

The relative times of working are not so good as those shown on another estate. One would have expected a greater margin in favour of the sheet rubber; but chief attention is drawn to the difference in weights.

Calculated on a basis of 100 lbs. of crêpe we find that 103 lbs. of sheet would be obtained. Presuming that the prices for sheet (smoked) and pale crêpe were equal, at the figure quoted to-day * —4*s.* per lb.—there would be a distinct gain on sheet of 12*s.* Dividing this sum by 100 we arrive at the result that relatively the pale crêpe would show a distinct loss amounting to 1·44*d.* per 1 lb. of rubber. Or, to put it another way, there would be a loss of 12*s.* on every 100 lbs. of crêpe prepared.

Other figures needed.

It need hardly be pointed out again that this difference in weight has nothing to do with moisture, but is a distinct loss of substances which are washed out of the rubber in the process of crêpe-ing. Furthermore, these substances are always contained in Fine Hard Para, and in all probability, apart from loss of "nerve" caused by the crêpe-ing process, it is the retention of these substances in sheet rubber which partially accounts for the fact that of all plantation grades only smoked sheet has the honour of being equal to, or superior to, Hard Para rubber.

This 3 per cent. is a greater difference than was found in

* March, 1913.

laboratory experiments, and it is stated that differences of as much as 4 per cent. in weight have been observed in Ceylon. It would certainly seem feasible to argue that the difference would be very much more marked if the latex were rich in total solids. Other results obtained on estates in Malaya show variations from 2 per cent. to 3 per cent. This is a very serious item, and one which must receive the greatest consideration from those now making pale crêpes. Quite apart from any other aspects of the case in which saving in preparation, of packing, of handling, etc., may be discussed, the actual loss of weight in preparing crêpe is great. To an estate which ships 30,000 lbs. of first-grade crêpe per month the annual loss at 1*d*. per lb. would amount to £1500.

Before one can tell what the actual total loss would be, one requires to have figures dealing with the following points in addition to those previously outlined:—

1. Relative costs of carting and freight.
2. Relative total costs of manufacture.

Concerning the latter point there is always much difference of opinion, although it is difficult to see why this should be so. It would be an easy matter, it is imagined, for any manager to obtain accurate information from the working of his own store. Singularly enough although the information has been asked for in several of the publications issued from this laboratory, in not more than two cases have managers been able to supply it. Probably most managers if asked for an opinion as to which cost the more per lb. to prepare, pale crêpe or smoked sheet, would say "smoked sheet." In the only two instances of reliable information which reached the writer the cost was worked out on the following comparative lines:—

(1) Time taken in handling and coagulating latex—
 (*a*) in dishes for sheet form;
 (*b*) in jars for crêpe form.

(2) Time taken in handling and coagulating prior to machining—
 (*a*) hand-pressing and rolling for sheet form;
 (*b*) cutting up for crêpe form.

(3) Time taken to roll rubber on machines—
 (*a*) for sheet form: twice through smooth rolls and once through pattern-rolls;
 (*b*) for crêpe form: through all machines from macerator to finisher, a total number of 15 times.

(4) Time taken to handle rubber for drying—
  (*a*) sheets hung in smoke-house;
  (*b*) crêpe hung in air-drying house.

(5) Time taken to dry in each case.

(6) Extra cost of fuel and labour to be added to smoked sheet.

As a result of these investigations it was found that sheet rubber suffered in comparison with crêpe rubber under headings (1) and (2); but that there was a striking gain in section (3). On the whole the total cost of preparation of smoked-sheet was found to be less than the cost of preparing crêpe rubber by an amount varying from $\frac{1}{4}$ to $\frac{1}{2}$ a cent.

On the other points, viz.:

period of drying,
drying space required,
number of boxes required for packing,
cost of handling and carting, etc.,

there can be no argument against the statement that the advantage lies with smoked-sheet. It has been shown, therefore, that having been given a choice of preparing either pale crêpe or smoked sheet, a manager would lose about $2\frac{1}{2}$ per cent. to 3 per cent. on the prevailing price of rubber if he continued to make pale crêpe; not only is this so, but the physical qualities of the rubber would be inferior to that of smoked sheet.

CHAPTER XVIII

PLANTATION RUBBER *VERSUS* FINE HARD PARA

It would be an extremely difficult task to elucidate the intricate and subtle reasons why manufacturers are willing to pay approximately 20 per cent. more for Fine Hard Para than for the best quality of plantation rubber. That they do pay this extra price must be evident since, although the two rubbers command approximately the same market price, plantation rubber is almost absolutely dry, while Fine Hard Para rubber contains anything from 15 per cent. to 20 per cent. of moisture. Obviously, therefore, when the manufacturer has crêped and dried Fine Hard he has so much less rubber. There must be a certain amount of truth in the remark that plantation rubber has had to force recognition from prejudicial minds in the rubber business, and it is fairly evident even yet that manufacturers have not given plantation rubber a fair trial. Some time ago it was the common belief that plantation rubber was ever so much weaker than "Fine Hard," and that superstition, although becoming more tenuous, takes a long time to die. From our point of view there are no doubts in the matter, as we have been able to show again and again that in one grade at least plantation rubber is equal, if not superior, to "Fine Hard." Probably the only objection with any weight is the question of lack of uniformity. Even on this point there is a small diversity of opinion, but in the main the most general complaint is lack of uniformity.

MANUFACTURERS' OPINIONS.

Some time ago (April, 1912) the collected opinions of manufacturers were quoted. The situation in the rubber world appears to have changed slightly since then; so that there is no reason why those opinions should be reproduced here. Manufacturers were asked for their opinions or experience of the relative values of different grades, the relative values of plantation smoke-cured sheet and Fine Hard Para, the effect of colour in plantation rubber, etc. The replies received varied so widely

in their vague generalities that one could not be justified, on the whole, in saying that any guidance was to be derived from them.

While some manufacturers stated that plantation rubber was always inferior to Fine Hard, others confessed that their experience of plantation rubber was extremely small or limited to one particular grade. This limited experience, however, did not deter them from giving an unfavourable opinion of plantation rubber, and it is probable that their experience was gained only from the handling of the lowest grades. It need hardly be pointed out that any opinion formed on a comparison between the lowest grades of plantation rubber in comparison with Fine Hard would be as valueless as an opinion upon the relative merits of iron from two sources if one was in the form of cast-iron, and the other in the form of best steel.

From the opinions of other manufacturers it was obvious that they were not aware of the best means of handling and treating plantation rubbers; while in a few isolated cases manufacturers said they had no difficulty whatsoever in using plantation rubber for any purpose. One manufacturer went beyond this, and stated that any rubber is as good as another for manufacturing purposes if treated rightly, and the difference in quality of the different rubbers was a myth as far as he was concerned.

It is to be noted that even on the question of rewashing plantation rubbers before use, no two opinions agreed. Some found it necessary to re-wash all grades, some only re-washed biscuits, sheets and scrap grades, others only re-washed scrap rubbers. There has been considerable change in the state of affairs during the last twelve months, and it is probable that the opinions of manufacturers have now been largely modified. It is fairly plain, however, that little guidance is to be gained from the opinions given.

UNIFORMITY. One point is made clear in a perusal of the manufacturers' views, and that is the conflict of ideas expressed in the word "uniformity." There has been more argument anent the lack of uniformity in plantation rubber than over any other point during the past three years. What exactly is implied by the use of the word "uniformity"? Does it refer to the non-variation in any one particular grade? The word certainly might be used in this sense. For instance, some estates make a standard first latex product, *e.g.* smoke-cured sheet, which to all

appearance does not vary month after month. Another estate may make a pale crêpe which, as far as can be judged by ordinary standards, does not change. In these cases it could be well said that the product was uniform, at least as far as slight daily variations in the rubber content of the latex will allow. Of most well-established estates it might be said, in this sense, that whatever the grade of rubber the output is uniform. Apparently, however, manufacturers as a whole do not use the word "uniformity" exactly with this implication. Seemingly Fine Hard Para is described as a uniform product because it is the only form practically in which first grade rubber is sent from the Amazon. In appearance it is all uniform. With plantation rubber, however, a first quality rubber may be air-dried sheet, smoked sheet, thin pale crêpe, thick blanket crêpe, smoked crêpe, thin block or thick block. This diversity of form is apparently a great stumbling-block to manufacturers; and it sometimes happens that a mixed lot of smoked sheet and pale crêpe has to be taken. From our knowledge of the intrinsic values of these two grades we should keep them separate, but this is what cannot always be done; and we are told that the two grades are often mixed in one batch. It would simplify matters very much for manufacturers if the plantations would combine to produce one type of first grade rubber. It must be remembered that pale crêpes are superior to any other form for certain processes and articles; but if there is to be any approach to uniformity of first grade type it would seem to be in the direction of smoked sheet, if the best standard is to be attained. This question of approaching towards a standard output is really more vast and important than most people imagine, and the difficulties in the path are very great. It is usually considered that the taste of the market at any time reflects the demand, and so we find that first one type of plantation first-grade rubber is in favour (*i.e.* obtains a higher price) and then another type supersedes it. In the meantime the individual who should have the power of deciding what is wanted (*i.e.* the manufacturer) is represented as the voice crying in the wilderness. It is of no avail for him to demand why plantations do not do this or do that, as the choice does not rest with the plantation. Who then is responsible for the change of type? Apparently only the dealer, who takes all the risks of keeping stocks and fulfilling orders from manufacturers. In the last three years it must have been very evident that estates which

have prepared but one type of first-grade rubber all through the varying demands have come out well. Especially does this apply to estates making smoke-cured sheet, and if it were thought for a moment that the advice would be taken seriously the writer would recommend all estates to commence preparing smoked sheet and maintain a uniform output at all times and under all fluctuating conditions of the market.

Concerning the grades below the first it can only be said that they will always be fairly uniform. Probably there is none now interested in plantations who imagines it possible to obtain eighty or ninety per cent. of the total output in first grade form, although it is related that one gentleman wanted to know why naturally coagulated lump and tree scrap were not made into sheet form, in the recent days when the difference in price between first grade and lower grades was so marked. At the best, as far as can be seen, there will always be twenty-five per cent. of the total output in the form of lower grades. With the increasing care now being bestowed upon these lower grades, and the similarity of methods employed in collecting and preparation, it may be said safely that there need be no complaint of lack of uniformity with regard to them in the future. It may be a mistaken idea, but in the opinion of the writer the first approach to uniformity in these grades must be through *uniformity of appearance.* This may not be attained as long as some estates prepare their lower grades of rubber in thin crêpe form, some in medium crêpe, and some in thick blanket crêpe. It would be preferable to have them all in one of the three forms. From a practical standpoint the best type would appear to be a thin crêpe, well washed and quick in drying. If the crêpe is rolled thick originally the chances are that it is badly washed and takes a very long time to dry. On the other hand the market appears to like lower grades of rubber in thick form; the apparent but false strength of thick rubber in crude hand tests would appear to please. For this reason it is probable that the best way of preparing low grade crêpes is to wash the rubber well and roll into thin form first; when dry these thin lengths can be rolled to any desired thickness. Unfortunately one cannot give this advice with any authority and it must remain for the present merely an expression of personal opinion.

Lack of uniformity in Hard Para.

If we accept the idea that uniformity is typified by a single product which *looks* uniform then Hard Para is certainly a uniform product. But from the view-point that uniformity is

attained by a product which is the same throughout and does not vary one part from another, it is easy to see that Fine Hard Para is no more a uniform product than the make of smoked-sheet from a well organised and established estate. In the first place the seringueiro of Brazil has a certain number of trees to tap, from the latex of which he builds up the biscuit day by day. It follows, therefore, that, as the possibility of latices from separate groups of trees being identical is infinitely remote, the physical qualities of rubbers prepared in different groups must vary. As a manufacturer points out, in this sense Fine Hard Para may be uniformly good or uniformly bad, much as smoked sheet from one estate may be always superior to the same product from another estate. There is a further consideration. It is well known from experience of plantations that the latex from any one group of trees may vary in periods or from day to day according to weather and other conditions such as the quantity of water placed in cups. The rubber, therefore, may vary in quality slightly from day to day, and in view of the fact that a large "biscuit" is the product of many days of labour it follows that the whole mass may be composed of parts which are not really uniform. It may be claimed therefore that the variation between smoked sheets produced on any two days from a plantation would not be greater than that in a corresponding weight of Fine Hard Para. Finally manufacturers know that in this respect specimens of Fine Hard Para do not exhibit general uniformity; there is poor rubber as well as good rubber, although both may seem alike when judged by superficial examination.

PLANTATION LATEX *versus* BRAZILIAN LATEX.

The idea that plantation rubber is much inferior to Fine Hard Para is gradually losing ground. In the past probably there may have been grounds for the belief, due to the lack of care exercised in preparation. Again, it was manifestly unfair to compare plantation crêpes with Fine Hard Para, just as it would be to compare them with smoke-cured plantation sheet. Yet this was universally done, when obviously crêpes should have been compared with the lower grades of Brazilian rubber. Thus arose the theory that—

1. The plantation trees were not the true *Hevea Brasiliensis* species.
2. Plantation latex must be inferior to latex from trees in Brazil.

The former suggestion has been refuted by many authorities

and may be dismissed without further discussion, while the latter may be shown to be equally untrue. In order to test the point, the writer prepared, on two occasions, rubber from plantation latex in the Brazilian fashion upon a spindle which was rotated in smoke. The smoke was generated from coco-nut husks and was conducted to the spindle or "paddle" by means of a tin cone. Only sufficient rubber was prepared in each case to carry out the tests. When cut from the paddle the samples took the form of thick, irregular sheet, a section of which showed distinctly fine parallel lines indicating the layers in which the rubber was built up. The rubber was dark in colour and had the odour typical of best plantation smoke-cured rubber. In the first experiment the smoke-curing was carried somewhat further than is the case with Fine Hard Para. The rubber was almost dry, whereas Brazilian Hard Para rubber, on arrival in England, is still opaque and contains 10 per cent. to 20 per cent. moisture. By the time the sample reached London it was quite dry. Tests were made upon it in comparison with a specimen of Fine Hard obtained from a manufacturer. The results were as follows :—

O. 22 . . . Fine Hard Para.
X. 26 . . . Plantation rubber prepared in Brazilian fashion.

	O. 22.	X. 26.
Resiliency	55	62
Resistance to stretching (elasticity)	112	146
Percentage recovery (sub-permanent)	91·8	94·6
Percentage recovery (Admiralty)	97·5	95·2

It will be seen that in the first three tests sample X.26 gives very high figures. In fact, in the first two tests the quality of the rubber is much higher than that of any other sample of smoked rubber we had so far tested. In the Admiralty test, however, the figure given is distinctly below the figure for Hard Para or for several of the best samples of smoked sheet. We have noted that this last figure tends to be a little low for samples which have been overheated. From this it is inferred that by curing to the dry stage the sample X.26 had been slightly charred.

The second sample was prepared some time later, and curing was not carried to dryness. The rubber was cut from the paddle, and was found to be quite moist. By the time it reached London, however, a great deal of the moisture had evaporated, and only about 3 per cent. remained. In order to make the comparative tests as stringent as possible, two specimens of the Fine Hard Para were obtained from a manufacturer,

who described them as being exceptionally strong and good. The samples vulcanised and tested were—

1. Plantation rubber, smoke-cured in Brazilian fashion.
2 and 3. Specimens of Fine Hard Para; said to be exceptionally strong.
4. A smoke-cured sheet; smoked sixty days.
5. Standard smoked sheet.

NUMERICAL RESULTS.

	1.	2.	3.	4.	5.
Resiliency	70·5	63·5	60	70·5	65·5
Resistance to stretching .	159	133	123	159	140
Recovery (sub-permanent) .	91·9	92·6	91·3	96·5	94·1

COMMENTS.

(*a*) The first point which stands out above all else is that the Fine Hard Paras, which were supposed to be exceptionally strong, prove to be the most inferior of the whole batch. This is striking, because the manufacturer who handed over the samples said that they were almost twice as strong as some samples of Hard Para. In fact, samples of Hard Para vary so much that they have to be blended after testing each batch to obtain uniform results in vulcanising. Contrast this with the charge of lack of uniformity brought against plantation rubber in comparison with Fine Hard Para.

(*b*) The standard selected for judging plantation smoked sheet is higher than the figures obtained by either the Fine Hard Para samples.

(*c*) The results given by sample No. 4, a good specimen of plantation smoke-cured sheet, are superior even to those of the plantation rubber prepared in Brazilian fashion.

From these results it will be apparent that any statement as to the inferiority of plantation latex must be quite erroneous, and readers may be assured that with reasonable care in preparation it is possible for plantations to ship rubber which would be superior to Fine Hard Para.

As further evidence of the high quality of plantation smoke-cured rubbers it is proposed to give figures of tests made at various times upon samples in comparison with specimens of SMOKED SHEETS AND

CRÊPES *versus* HARD PARA.

Fine Hard Para obtained from manufacturers. It will be shown later that there has been a great advance in the quality of plantation smoke-cured rubbers, so that any differences shown at the time of these tests (1911) are now much greater.

(1) A small batch of average plantation smoke-cured rubbers.

S. 23. Smoked Sheet from Estate No. 6
T. 23. ,, Crêpe ,, ,,
U. 23. ,, Sheet ,, No. 11
V. 23. ,, ,, ,, No. 7
W. 23. ,, ,, ,, No. 1 (bottom tappings)
X. 23. ,, ,, ,, No. 1 (top tappings)
O. 22. Fine Hard Para.

In the subjoined table the samples are arranged in the order of quality under each test. Number one is the best sample and number seven the worst.

ORDER OF QUALITY.

Sample.	Hysteresis loop tests. Extension. 1st cycle.	Extension. 5th cycle.	Angle of resiliency.	Percentage recovery.	Resistance to stretching.	Admiralty test. Recovery in ½ hour.	Recovery in 6 hours.	Total.
S. 23	3	2	2	4	3	2	2 (bracketed)	18
T. 23	6	7	7	7	6	7	6	46
U. 23	2	3	4	5	2	6	5	27
V. 23	1	1	1	1	1	1	1	7
W. 23	4	4	3	2	4	5	4	26
X. 23	5	5	5	3	5	4	3	30
O. 22	7	6	6	6	7	3	2 (bracketed)	38

N.B.—The higher the total the lower the quality.

Too much weight must not be attached, however, to the place figure given under each test, as in many cases the difference between any two samples consecutive in quality was extremely small, amounting in some cases to only 0·1 per cent. The table is only given as a rough illustration of how the actual results compared in order of merit. It is noteworthy, however, that the sample V. 23 was first in quality in each test, and that in the Admiralty test sample S. 23 also gave better results than

O. 22, the sample of Hard Para. The only sample of crêpe, T. 23, was inferior to all the other samples which were of more than average quality. The smoked sheet from bottom-tappings was slightly superior to that made from top-tappings, but the difference was not very great.

(2) A batch composed of the following samples was tested:—
13 samples of smoked sheet.
2 samples of smoked crêpe.
1 sample of partially-smoked block.

The samples were contributed from six different estates, and three of them were experimental samples prepared by the resident chemist. There were also two older samples dating from May and June of 1910. These had not been submitted to thorough smoking.

The samples were arranged in their order of merit under each distinctive test of Resiliency, Elasticity, and Recovery after short and prolonged stretching.

A table was also prepared, as a summary upon the foregoing, in which equal weight was given to each test, and the order of merit decided by taking the four tests together.

TABLE I.

SAMPLES ARRANGED IN ORDER OF MERIT ACCORDING TO FIGURES GIVEN IN EACH TEST.

	Resiliency.	Resistance to stretching.	Percentage recovery (Sub-permanent).	Percentage recovery (Admiralty test).
1 . .	R. 22	E. 24	V. 23	S. 22
2 . .	S. 22	R. 22	S. 22	V. 23
3 . .	V. 23	V. 23	E. 24	S. 23
4 . .	E. 24	U. 23	W. 23	**O. 22**
5 . .	S. 23	S. 22	R. 22	X. 23
6 . .	W. 23	F. 24	X. 23	W. 23
7 . .	V. 23	S. 23	S. 23	R. 22
8 . .	V. 20	W. 23	C. 24	E. 24
9 . .	F. 24	V. 20	U. 23	U. 23
10 . .	X. 23	X. 23	**O. 22**	V. 20
11 . .	**O. 22**	C. 24	F. 24	C. 24
12 . .	T. 23	D. 24	V. 20	Q. 19
13 . .	C. 24	W. 21	W. 21	M. 19
14 . .	D. 24	T. 23	Q. 19	W. 21
15 . .	W. 21	**O. 22**	T. 23	F. 24
16 . .	Q. 19	Q. 19	D. 24	T. 23
17 . .	M. 19	M. 19	M. 19	D. 24

Samples bracketed together are of equal quality under the particular test.

The two old and imperfectly smoked samples are Q. 19 and M. 19. These show a uniformity which is undesirable.

Fine Hard Para (O. 22) does not show up at all well in the first three tests.

TABLE II.

SAMPLES ARRANGED IN ORDER OF MERIT SUMMARISING ALL THE FOUR TESTS GIVEN IN THE PREVIOUS TABLE.

Order of quality.	Sample.	Description of sample.
1	V. 23	Smoked sheet from Estate No. 7
2	S. 22	,, ,, ,, No. 1; prepared experimentally by the writer and smoked longer than usual
3	R. 22	Smoked sheet from Estate No. 1; prepared experimentally by the writer from the latex of four-year-old trees; to compare with sample V. 20
4	E. 24	Smoked sheet (1) from Estate No. 10
5	S. 23	,, ,, ,, No. 6
6	W. 23	,, ,, ,, No. 1: bottom-tapping
7	U. 23	,, ,, ,, No. 2
8	X. 23	,, ,, ,, No. 1: top-tapping
9	V. 20	,, ,, ,, No. 1: latex from four-year-old trees
10	F. 24	,, (2) ,, No. 10
	O. 22	Brazilian Fine Hard Para
	C. 24	Smoked sheet from Estate No. 9
11	W. 21	,, crêpe ,, No. 1
12	T. 23	,, ,, ,, No. 6
13	Q. 19	,, sheet ,, No. 1: old and poor sample
14	D. 24	Partially smoked block from Estate No. 10
15	M. 19	Smoked sheet from Estate No. 1: old and poor sample

COMMENTS.

Excluding the old samples of smoked sheet made in the early part of 1910, all the samples of smoked sheet tested were either equal to, or superior to, the comparative sample of Fine Hard Para.

The quality of smoke-cured sheet appears to depend more upon conditions of coagulation and smoking than upon the age of the trees from which latex is obtained. The leading sample was prepared from mixed latices obtained from trees varying

from four years to thirteen years of age; while one of the best samples came from four-year-old trees.

It is evident that in all cases the rubber should be thoroughly smoke-cured, and it is advantageous to allow the rubber to remain in the smoke-house for a longer period than that necessary for drying alone.

Of the seventeen mixed samples, Fine Hard Para was bracketed in the tenth position only; from which it may be inferred that the so-called inferiority of plantation rubbers is not an actuality.

(3) A batch of more modern plantation smoke-cured rubbers, in comparison with samples of Fine Hard Para selected by a manufacturer as being exceptionally strong.

These samples are taken haphazard from those submitted during the year 1912, and comprise smoke-cured sheets and crêpes.

1. First grade crêpe; smoked 27 days: Estate 9.
2. Crêpe from naturally coagulated lump; smoked 27 days: Estate 9.
3. Crêpe from tree-scrap; smoked 27 days: Estate 9.
4. Smoked sheet; average make: Estate 29.
5. " " many air bubbles: Estate 9.
6. " " average make: Estate 18.
7. " " with sodium bisulphite: Estate 18.
8. " crêpe; from "lump" rubber: Estate 23.
9. " sheet (1); poor appearance: Estate 23.
10. " " (2); good medium appearance: Estate 23.
11. " " (3); fine (pale) colour: Estate 23.
12. " " ribbed pattern: Estate 10.
13. " " diamond pattern: Estate 10.
14. " " average make: Estate 3.
15. " " lime-treated peaty water in cups: Estate 25.
16. " " smoked one month: Estate 26.
17. " " average make: Estate 26.
18. " " average make: Estate 18.
19. " " special care in preparing: Estate 10.
20. " " ordinary preparation: Estate 10.
21.–22. } Exceptionally strong samples Fine Hard Para.
23. Standard smoke-cured plantation sheet.

Sample.	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
1 . .	68·5	141·2	95·3
2 . .	69·3	143·5	94·3
3 . .	67·3	130·2	93·8
4 . .	65·3	135·0	92·9
5 . .	63·1	132·0	93·8
6 . .	67·9	144·0	92·0
7 . .	72·2	155·0	94·6
8 . .	65·5	147·0	93·7
9 . .	65·5	143·0	92·9
10 . .	69·5	160·0	94·7
11 . .	65·5	149·0	93·5
12 . .	70·0	146·0	96·5
13 . .	71·5	152·0	96·2
14 . .	64·5	133·0	90·9
15 . .	67·9	137·2	95·9
16 . .	73·9	158·3	97·7
17 . .	69·9	156·1	96·5
18 . .	69·5	138·3	94·7
19 . .	73·0	162·0	97·0
20 . .	69·2	149·0	96·4
21 . .	63·5	133·0	92·6
22 . .	60·0	123·0	91·3
23 . .	65·5	140·0	94·1

Glancing through the results given above one is struck by the fact that only one sample of plantation smoke-cured rubber fails to show superiority to the specimens of Fine Hard Para, and that particular one is quite their equal in quality. On the other hand one cannot but be struck by the fact that the large majority of the plantation samples surpass in quality the Standard Smoked Sheet. This standard was obtained some time ago by blending specimens of smoked sheet from a number of estates. Probably there will be reason shortly to raise again this standard, which is already a high one. It must be very evident now that so far from being generally inferior to Fine Hard Para plantation, smoke-cured rubbers are superior in the majority of cases. It is not argued here that plantation rubber as a whole is superior, or equal, to Fine Hard Para, for it has already been pointed out that ordinary air-dried crêpes are always inferior to the same class of smoke-cured rubbers, and, as a rule, much more inferior to smoke-cured sheet rubber.

Washed and unwashed rubber in testing.

It has been pointed out that in all the comparative tests between Fine Hard Para and plantation smoke-cured samples the Brazilian rubber was supplied in the form of crêpe by the manufacturer, whereas the plantation samples, being clean and

dry, were used without recrêping and washing. This we claim to be an advantage for plantation rubbers. But it is suggested that this difference in the preliminary treatment had an effect upon the vulcanisation tests. In order to decide whether or not there might be some truth in the suggestion, it was considered advisable to recrêpe (and wash) some smoked sheet and compare it with an unwashed portion of the same sheet.

(1) A smoked sheet was taken and halved.

One half was used in the unwashed form, A.

The other half was recrêped, washed and dried, B.

Numerical Results of Tests.

	A.	B.
Resiliency	58·0	58·0
Resistance to stretching	127	126
Recovery (sub-permanent)	91·5	92·0
Recovery (Admiralty)	97·2	97·6

It will be seen that there is practically no difference between the results.

(2) A dark smoked sheet was halved, and the two halves were tested against a pale smoked sheet from the same estate. This pale sheet was merely introduced to illustrate another point.

(A) Original unwashed half.
(B) Washed (crêped) half.
(C) Pale smoked sheet.

Numerical Results.

	A.	B.	C.
Resiliency	56·5	56·5	57·5
Resistance to stretching	128·0	128·0	133·0
Recovery (sub-permanent)	94·0	93·5	94·6
Recovery (Admiralty)	94·6	94·1	95·2

Here again we see that any difference between A and B is negligible, but incidentally another point is brought out, viz. that persons used to looking upon colour as one of the guides to the quality of smoked sheets are liable to be very much deceived. It does not follow because a sheet is dark and appears strong that it actually is so.

Curing period.

It has been suggested several times in these pages that an improvement in quality results from a period of curing extended beyond the time necessary to dry the rubber. Proof of this statement has yet to be given, and will be found overleaf.

(1) The first case to be considered is that of a batch of crêpes which were smoke-cured directly after rolling.

Samples:—All crêpes prepared with minimum of acetic acid.

(*a*)
- A. 38 Smoke-dried to dryness only
- B. 38 " " " + 1 week extra
- C. 38 " " " + 2 weeks "
- D. 38 " " " + 3 " "

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
(*a*) A. 38 . .	64·5	136·3	94·4
B. 38 . .	65·2	138·8	94·2
C. 38 . .	65·9	139·0	95·1
D. 38 . .	66·5	136·1	95·1

There is evidently a continued improvement in the quality of the rubber with prolonged smoke-curing, but this improvement does not appear to be more marked after three extra weeks than after two extra weeks. It may be remarked incidentally that these smoke-cured crêpes are of a very high standard, being all practically equal in quality to standard smoked sheet.

(2) A batch of smoke-cured sheet rubber.

The series consisted of—

(1) Sheet, air-dried only.
(2) " smoked to dryness only.
(3) " " " + 1 week extra smoking.
(4) " " " + 2 weeks " "
(5) " " " + 3 " " "
(6) " " " + 4 " " "

The numerical results shown were—

	Total figures.
(1)	253·9
(2)	274·9
(3)	291·6
(4)	308·6
(5)	308·3
(6)	306·7

It may be noted that—

(*a*) All the smoke-cured samples were much superior to the air-dried specimen.

(*b*) There would appear to be practically no difference between samples (4), (5), and (6).

(*c*) The difference between samples 2 and 3 is greater than that between any other two smoke-cured samples.

(*d*) The maximum benefit would appear to be derived, in these particular samples, by two weeks' extra smoke-curing. It would be impossible, however, to say that this would apply to all specimens of smoke-cured rubber.

(*e*) It is certain that there is an improvement in quality with prolonged smoke-curing.

IMPROVEMENT IN STANDARD.

It will have been noticed by readers that reference was made to this point in the paragraph dealing with the respective merits of Fine Hard Para and plantation smoked rubbers. It was there shown by actual results that what was only a short time ago accepted as a high standard for smoke-cured sheet, is now likely to be superseded by a standard still higher. There is not the slightest doubt in the writer's mind that this improvement has been general, and that it continues to be made. From time to time in the course of tests upon plantation samples we have met with specimens which were acknowledged in the writer's local reports to be the best specimens hitherto tested. Each, in turn, has been surpassed by others, and what was the best of a year ago, has now become the average of to-day. To give an example, the following results, taken from the local report for July, 1911, may be compared with the standard smoked sheet now becoming out of date, and a few examples of more modern smoke-cured rubber.

Samples :—

B. 28	Experimental smoke-cured sheet	1911
C. 28	,, ,, ,,	
D. 28	,, ,, ,,	
S.	Standard smoked sheet (present)	
Z. 25	Smoke-cured sheet	1912
K. 36	,, ,,	
L. 36	,, ,,	
Z. 37	,, ,,	

N.B.—The results given by B. 28, C. 28, and D. 28 are recorded (page 4, July Report, 1911) as being extraordinarily high. No samples previously tested had given equal results.

Sample.	Resiliency.	Resistance to stretching.	Recovery (sub-permanent).	
B. 28	65·0	154·0	96·0	Highest recorded, July, 1911
C. 28	65·0	150·0	55·8	
D. 28	64·0	153·0	95·5	
S.	65·5	140·0	94·1	
Z. 35	69·6	160·0	94·7	Some 1912 samples
K. 36	70·0	146·0	96·5	
L. 36	71·5	152·0	96·2	
Z. 37	73·9	158·3	97·7	

CHAPTER XIX

CHOICE OF COAGULANT

In the past there may have been an idea common amongst planters that the possible coagulants of latex from Hevea Braziliensis were extremely limited in number, and that the choice generally lay between the use of acetic and formic acids. The results of experimental work published at intervals during the past three years must have gone far to correct such an erroneous idea, and most planters are at least aware that all the simple organic acids can be used as coagulants as well as the mineral acids and many salts. The first paper of interest on the subject of coagulants was published by Parkin in "Science Progress," Vol. IV., p. 596, 1910. A list of coagulants together with quantities there appeared, as below :—

	Gms. per 100 c.cs. latex.
Sulphuric acid	0·10
Hydrochloric acid	0·10
Nitric acid	0·30
Acetic acid	0·95
Oxalic acid	0·20
Tartaric acid	0·25
Citric acid	0·50
Mercuric chloride	0·80
Formic acid (Spence)	0·45
Potassium acid tartrate	0·16

These results are not found to be in agreement generally with those obtained by the writer, and in the case of acetic acid Parkin's quantity is nearly 10 times the quantity now commonly recommended for estate purposes. There were several other grave errors in the article. For instance, it is stated that if the usual quantity of sulphuric acid be doubled coagulation will be incomplete. This is not so, and in point of fact the writer has not yet succeeded in finding any real maximum beyond which it was inadvisable to proceed with this acid. Even in his

work on the commonest of coagulants, acetic acid, Parkin does not seem to have been fortunate. He asserts that the quantity of coagulant required is independent of the dilution of the latex even to the extent of dilution by 2000 volumes of water. How such a conclusion was arrived at is a mystery, as the writer finds the limit of dilution with ordinary dilute estate latex (about 20 per cent. dry rubber content) to be about three or four volumes. Any additional dilution beyond these quantities necessitates an increase in the quantity of coagulant. The peculiar fact is to be noted that while Parkin asserted that the quantity of acetic acid necessary is independent of the dilution of latex, at the same time he advanced the theory that coagulation of latex is the result of coagulation of the protein substances in the latex. These two statements are contradictory as it is known that coagulation of proteins varies with the state of dilution.

As being of general interest a short list is here given of some of the coagulants used successfully in our laboratories. Some are of commercial and others only of experimental value. The quantities were found by trial with fairly rich latex, of specific gravity about 0·9830 (about 28 per cent. to 30 per cent. dry rubber content).

1 % Solutions.	Vol. in c.cs.	Gms. per 100 c.cs. latex.
Sulphuric acid	10	0·10
Hydrochloric acid	8	0·07
Nitric acid	10	0·10
Acetic acid	10	0·10
Oxalic acid	12·5	0·125
Tartaric acid	17·5	0·175
Citric acid	18·0	0·18
Formic acid	8	0·08
Hydrofluoric acid	5	0·05
"Purub"	4	0·044
Mercuric chloride (5 %)	45	2·25
Barium chloride	100	1·00
Calcium chloride	50	0·5
Magnesium chloride	50	0·5
Sodium chloride (10 %)	50	5·0
Aluminium sulphate	100	1·0
Magnesian sulphate	100	1·0
Tannic acid	10	0·10

Many other chemical substances have been experimented with giving varying degrees of success, but the results are not of sufficient general interest to warrant their inclusion in these

pages. It will now have been made plain that the number of possible coagulants is a very wide one, but at the same time the choice of coagulant is rather limited for various reasons. At the present time there would appear to be no coagulant so eminently suitable for a coagulant as acetic acid. The scare raised in the earlier days of plantation rubber by manufacturers and brokers against the abuse of acetic acid is now proved to have been quite unwarranted, and as a result of continuous work we are in a position to affirm that even a slight excess of acetic acid has no deleterious effect upon the vulcanised product. It is rather interesting to remember the outcry against the employment of acetic acid, and to balance against it the fact which was continually being overlooked, viz.: that the agent of coagulation in the preparation of Fine Hard is the acetic acid contained in the smoke. In point of fact, as will be shown later, Find Hard Para is often much more acid in nature when it arrives on the market than plantation rubbers which may have been prepared with an excess of acetic acid. Acetic acid possesses two or three excellent qualities which render it so eminently suitable for estate purposes. It is fairly cheap, it is not dangerous to handle, and it can be used with wide limits, a slight excess being of no consideration. Some little time ago an attempt was made to boom a process of coagulation by means of carbonic acid gas. Its advocate and patentee, Dr. Pahl of Dortmund, delivered a lecture upon it at the Rubber Exhibition of last year. The discussion which followed severely damaged the claims put forward by Pahl, and left one with the impression that some of the statements made by that gentleman had no foundation in facts. Reference will be made to this point later.

ACETIC ACID.

CARBONIC ACID GAS.

Briefly the scheme of coagulation is this. From a cylinder of liquid carbon-di-oxide, the gas is allowed to escape, under reduced pressure, into a vessel containing latex. According to Pahl coagulation is almost immediate and complete.

In a recent article Pahl indulges in the following outburst:—

"The science of chemistry has at last obtained the victory and torn the veil aside which had been hanging over the mystery of Para rubber. The whole world and all the Hevea plantations in particular have thereby gained an enormous advantage. It has been discovered that carbonic acid is the agent which ensures to the cultivated rubber the victory over all procedures heretofore employed."

The whole article is written in that strain and contains

statements of such a wild and astonishing character as to stamp its author either as a brilliant advertiser or as one out of touch with the rapid advancement made by all grades of plantation rubber.

After a lengthy account of the method employed in the Brazilian process of preparing smoked rubber, he says:—

"The smoke is more or less a secondary symptom, and serves during the process chiefly as a carrier of carbonic acid caused by combustion, which is drawn upwards by the smoke. The smoke also may contain other substances, such as creosote, which preserves the rubber from mould and prevents it perishing; but it is less important in these things than that in the present case it is the carrier of carbonic acid. It must also be further taken to consideration that the seringueiro pours the latex over the paddle only while it is in a fluid condition, and to this end always *makes fluid again* such rubber as has already coagulated previous to smoking. It is obvious that this liquid latex must coagulate instantly on the paddle as otherwise it would flow off again. It is carbonic acid which effects the instant coagulation."

A vast number of general mis-statements were made, all tending to show that coagulation with carbonic acid gas was the finest discovery of the planting age. Contrast this with the fact that in the course of experimental work in your laboratory the present writer found it impossible to obtain effective coagulation with carbonic acid gas. It is not advanced that the patentee had never done any experimental work on the subject, although that would appear possible. We know that experimental work was done in Sumatra, but we venture to point out that the coagulation obtained was not the result of carbon-di-oxide, but was effected by the fine particles of hydrochloric acid carried over by the bubbles of gas from the generating apparatus. What is certain is that if dry pure carbon-di-oxide is used from a cylinder it is impossible to obtain anything approaching complete coagulation. After two years this has been recognised by the patentee, who has now amended his process so that by passing the gas from the cylinders into hydrochloric acid sufficient of the latter may be carried over to effect complete coagulation.

FORMIC ACID.

Of formic acid it may be said at once that it is equally as good as acetic acid, and that its use may be safely recommended. At the same time too much attention need not be given to pamphlets written with the design to boom formic acid at the expense of acetic acid. The writer is so often asked for an opinion of the

respective merits of these two coagulants that he cannot do better than reprint a criticism of a pamphlet which came into his hands some little time ago. The full criticism appeared in Report No. 4, 1912.

"At the outset it is only fair to acknowledge that the firm in question are to be complimented upon the style of the pamphlet and the business acumen which is responsible for its appearance; but it must be always remembered that it is an advertisement and, as such, one must not accept all the statements made therein without certain reservations.

The writer of the pamphlet has evidently taken advantage of the privileges of an advertiser and has summoned to his aid all the "heavy guns" of the literature dealing with the processes of coagulation. Unfortunately the statements given as quotations from these writers do not coincide with the results obtained in the research work carried out here during the past few years, so that the value of those facts is not at all commensurate with the importance accorded them by the writer of the pamphlet under discussion. As the writer depended entirely upon these quotations for the foundations upon which to build his superstructure, it follows that the whole argument becomes unstable, and the points which he sets out to make, in favour of the use of the article which he wishes to boom, become null and void.

Is latex naturally alkaline?

Neglecting a long preamble upon the process of coagulation which contains nothing beyond the usual elementary knowledge, and noticing that Henri is often quoted, we come across the following statement:

"For an effective and rapid coagulation the natural alkalinity of the latex must be suppressed."

Then, in order to show (presumably) the alkalinity of latex, an experiment is described in which the latex is treated with a trace of "soda"!

In this country our difficulty is that often in spite of clean cups and pure water the latex coagulates before it reaches the coagulating station. This would indicate, to the average man, the presence of acid. This opinion is confirmed in the laboratory where it is found that latex brought less than a hundred yards during the ordinary course of work is distinctly acid. On being allowed to stand it is found that the acidity continuously increases. We are not concerned here with the prime causes

of this acidity, but sufficient has been written to show that we can base no arguments upon the natural alkalinity of latex.

Relative coagulating power of formic and acetic acids.

A few pages of arguments then follow and the writer ends the chapter by bringing forth in large type the fact that it is advisable to "coagulate the latex with acid agent," a conclusion which has lost the beauty of its pristine youth. The main arguments in this chapter appears to be a desire to prove that formic acid is the cheapest in use. To arrive at this fact the writer says:—

"Theoretically 46 parts of our 90 per cent. formic acid are equal in acidity to 60 parts acetic acid 90 per cent."

Relative cost of formic and acetic acids.

This is perfectly true, but unfortunately he omits to give the actual selling prices of the acids so that an adequate comparison might be made. The prices charged by the firm have been given me as:—

Formic acid.	Acetic acid.
per lb.	per lb.
23¼ cents	16¼ cents.

Before we proceed to calculate an actual comparison in combination of power and prices it should be pointed out that there is another factor needing consideration, viz. that the strongest formic acid sold gives 90 per cent. acid, while the acetic acid usually sold to plantations = 99 per cent.

We have then three factors to consider:—

(*a*) Power to work,

(*b*) Price,

(*c*) Concentration,

combining these three for each acid we arrive at the following comparison:—

Formic acid.		Acetic acid.	
$46 \times 23\frac{1}{4} \times 90$	:	$60 \times 16\frac{1}{4} \times 99$	which works at
2,139	:	2,145	or practically
1	:	1	

That is to say, there is practically no difference between the two.

Proportions to be used.

In support of a statement that comparatively less formic acid is required than acetic acid to coagulate the same volume of latex, a quotation is given from an article by Spence which appeared in the *India Rubber Journal*, 1908. We have no desire to disagree with the statement which, in its general

application, is perfectly correct, but not so the figures quoted (probably Spence worked with latex which had been treated with ammonia or formalin).

Spence found that for 100 c. centimetres of latex, to obtain complete coagulation, there was required respectively—

18–20 c.cs. of a 5 per cent. solution acetic acid.
8–10 ,, 5 per cent. ,, formic acid.

The writer of the pamphlet then says:—

"These figures speak for themselves and need no further explanation."

Let us examine these figures and it will be found that they *do* speak for themselves, but unfortunately do not speak the exact truth. Taking the acetic acid first, we see that Spence used only 9 *to* 10 *times as much* acid as we use every day in our factories. For 100 c.cs. of latex, to obtain complete coagulation, only 2 c.cs. of a 5 per cent. solution of acetic acid are really necessary, or 10 c.cs. of a 1 per cent. solution.

Turning next to the formic acid, it has been found in actual practice in the local laboratory that the minimum quantity of acid required per 100 c.cs. latex is 7·5 c.cs. of a 1 per cent. solution (*i.e.* 1·5 c. cs. of a 5 per cent. solution).

Compare then the correct figures given below with those given by Spence.

Required for Complete Coagulation per 100 c.cs.

2 c.cs. of a 5 per cent. solution acetic acid
(10 c.cs. 1 per cent. solution.)
1·5 c.cs. of a 5 per cent. solution formic acid
(7·5 c.cs. 1 per cent. solution.)

It is quite probable, however, as before stated, that Spence worked with preserved latex, and that the small quantities of latex used tended to enlarge the error of experiment.

On these results found in the Kuala Lumpur laboratory, therefore, it is necessary to re-state the calculation affording all round comparison between the two acids, as follows:—

Formic acid.		Acetic acid.	
7·5	:	10	(Power)
23¼	:	16¼	(Price)
90	:	99	(Concentration)

and in combination

$$7\cdot5 \times 23\tfrac{1}{4} \times 90 \ : \ 10 \times 16\tfrac{1}{4} \times 99$$

$$\text{or} \qquad 132\cdot5 \ : \ 143$$

which again is practically $1 : 1$

but slightly in favour of acetic acid.

The rest of the pamphlet contains many statements, some founded upon erroneous figures, and others upon erroneous ideas. For instance, as a proof of the benefit to be derived from the use of formic acid an experiment is described in which Spence placed in contact a tacky piece of African rubber and a piece of rubber prepared with formic acid. It is noted that after several months tackiness had not spread from the affected piece to the clean rubber. But no superior claim can be based on such fact, for it is the ordinary phenomenon observed when acetic acid rubber is preserved under like conditions.

Neither should the fact that formic acid rubber did not develop tackiness when kept at a temperature of 37° C. [98·6 F.] have any weight. Under ordinary circumstances the temperature of our air-drying sheds during the day-time is quite that figure, and our smoke-houses ordinarily work at a temperature ranging from 100° F. to 120° F. without causing signs of tackiness.

Proportions recommended by the vendors.

The writer again summons Spence to his aid in the chapter upon the proportions of formic acid for use. He is described as having found that best results were given by using for each 100 parts of latex 4 or 5 parts of a 5 per cent solution (=20 to 25 parts of a 1 per cent. solution). For the benefit of those who may like to try the acid it must be stated again that *these figures are much too high*, and that for 100 parts of latex only 7·5 parts of a 1 per cent. solution are necessary to secure complete coagulation, *i.e.* about $\frac{1}{3}$ the quantity prescribed by Spence.

After wasting space and printers' ink in an argument about the use of a mixture of acetic acid and ± 5 per cent. carbolic acid (whatever "plus or minus" may mean in this connection), and its application to the preparation of "damp block rubber," the writer concludes by quoting from Herbert Wright a method of determination of the exact quantity of acid for use. The method is an exact one and quite sound, but such as were better employed in a laboratory. In these days when the proportion of acid used has been reduced to about one-tenth the minimum advocated two or three years ago, the presence of a slight excess of a 1 per cent. solution need not be feared, and if any manager

wishes to try formic acid I should advise him to use slightly less of this acid than he is at present using of acetic acid, according to the figures given by me in the foregoing paragraphs."

To sum up the relative merits of acetic and formic acids it might be said that:—

(*a*) In bulk formic acid is dearer than acetic acid.
(*b*) In power to coagulate formic is stronger than acetic acid.
(*c*) In concentration acetic acid is higher than formic acid.
(*d*) Taking a combination of the three foregoing facts there is no difference between the two acids.
(*e*) There is no difference in the physical qualities of the rubbers prepared with a minimum quantity of either acid.

Other organic acids such as citric acid, tartaric acid, oxalic acid, tannic acid, etc., might be used as coagulants under some circumstances, but they do not compare in price, economy of use, or results with acetic acid. Further consideration of them, therefore, is unnecessary. Mineral acids might very well be used for coagulation, but are not to be recommended generally owing to their corrosive nature and the consequent danger attached to their use. Furthermore, with the use of hydrochloric acid it is found that the maximum proportion possible lies very closely to the minimum; it is thus easily possible that non-coagulation would result from the use of an excess of coagulant. If it were not for its exceedingly dangerous nature sulphuric acid would undoubtedly be the best all-round coagulant. Used in minimum proportions it is a wonderfully good coagulant and appears to yield a rubber quite equal to that obtained from the use of acetic or formic acids. Moreover, in dilute solution a slight excess does not appear to have any harmful effect upon the vulcanised rubber. With the use of a slight excess it produces a pale rubber. Its cost is only about one-half that of acetic acid and its efficiency is greater. These advantages are outweighed by its excessively dangerous nature, in most cases. Where, however, the factory is in charge of a responsible European who may be entrusted with the dilution of the concentrated acid, there should be no objection to the use of such an extremely valuable agent.

Other organic acids.

MINERAL ACIDS.

It will have been evident from the foregoing general remarks that coagulation with other chemical substances possesses only experimental interest and can be of no practical importance. In fact some of these substances are known to have an extremely

VARIOUS OTHER CHEMICALS.

harmful effect upon rubber. Hydrofluoric acid has been much spoken of at various times during the past few years, but its dangerous nature renders it most unserviceable. A dilute solution of this acid is sold under the name of "Purub," and while effective in coagulation there is absolutely nothing in the claim that the rubber so prepared is superior or purer than any other. On the other hand, its cost is ever so much greater than that of acetic acid.

Working with latex of specific gravity ·9830 (about 28 per cent. to 30 per cent. dry rubber content) the writer worked out the cost of using several of the better known coagulants, calculated per lb. of dry rubber obtained.

	Cents per lb. of dry rubber. (100 cents = 2s. 4d.)	Cents per 1000 lbs. of dry rubber.
Sulphuric acid	0·009	9
Nitric acid	0·012	12
Hydrochloric acid	0·018	18
Acetic acid	0·018	18
Formic acid	0·015	15
Oxalic acid	0·009	9
Tartaric acid	0·048	48
Citric acid	0·054	54
Hydrofluoric acid	0·063	63

SULPHUROUS ACID.

Recent experiments were made in the laboratory with a cylinder of sulphur-di-oxide supplied by Messrs. Boake Roberts & Co. It was well known that the prevention-of-oxidation effect obtained by the use of sodium bisulphite was due primarily to the sulphur-di-oxide gas set free. If it were possible to coagulate latex by passing the gas into it the effect could be expected to be more marked.

Sulphur-di-oxide gas in itself is not a coagulant, but it is easily dissolved in water yielding an acid solution. The gas was bubbled into latex contained in a tall beaker, and in a short while coagulation was apparent. It was never perfectly complete, however, and this was ascribed to the fact that the strength of solution increased so rapidly that the maximum was soon reached. By passing the gas through a series of water bottles strong solutions (about 5 per cent.) of sulphurous acid were obtained. With this solution experiments in coagulation were made and the results obtained were very successful. Without the necessity of using sodium bisulphite very fine crêpes of a beautiful colour

were prepared. With an excess of the sulphurous acid solution varying shades of fine pale colour can be obtained, equal to anything which could be effected with the employment of acetic acid and sodium bisulphite.

In the event of sulphurous acid being used fairly extensively it would be necessary to import cylinders of sulphur-di-oxide from which the solution could be prepared in factories each day. There would be no insurmountable difficulty in this, as it is only necessary to pass the gas through a series of closed vessels containing water. Enough solution could be prepared at one time for three or four days, but preferably the solutions should be as fresh as possible. Altogether there would seem to be great possibilities in the use of sulphurous acid for preparing pale crêpe rubbers, providing the cost is within comparable limits with the commoner coagulants at present in use. On this point we have no definite information at present, but it is expected that the cost will exceed that of acetic acid. If the cost did not exceed the combined cost of acetic acid and sodium bisulphite the employment of sulphurous acid solution might be worthy of consideration. There is only one drawback to the use of sulphurous acid solution, and that lies in the proximity of the limits of the quantities necessary for coagulation and that which is in excess and prevents coagulation. Thus with ordinary field latex having about 21 per cent. dry rubber content the minimum necessary for coagulation per 100 c.cs. of latex is about 8 c.cs. of a 1 per cent. solution. The maximum quantity possible for use is about 15 ccs. of a 1 per cent. solution, so that great care would have to be exercised in avoiding an excess of coagulant, otherwise coagulation would be effectually prevented.

TESTS ON RUBBERS PREPARED WITH COAGULANTS OTHER THAN ACETIC ACID.

It has been the rule in all the research work carried on in your laboratory that no opinion was given on any process of coagulation until the rubbers so prepared had been subjected to vulcanisation tests. Of these there have been scores, some of which are here shown.

REFERENCES.

J. 27	Sheets, coagulated with hydrochloric acid.
K. 27	,, ,, ,, sulphuric acid.
L. 27	,, ,, ,, nitric acid.
M. 27	,, ,, ,, oxalic acid.
U. 27	,, ,, ,, formic acid.
S. 20	,, ,, ,, acetic acid (old sample).

LIST OF NUMERICAL RESULTS.

	J. 27.	K. 27.	L. 27.	M. 27.	U. 27.	S. 20.
Resiliency . . .	48	49	48	50	47½	51½
Resistance to stretching (elasticity)	97	94	93	92	89	102
Recovery after stretching (sub-permanent)	83·6	83·5	83·6	83·9	83·4	83·7
Recovery after stretching (Admiralty)	84·0	84·0	84·1	84·4	85·1	84·3

Comparing these figures we find there is extraordinarily little difference between them, and that on the whole they approximate the figures given by the sample S. 20 which was coagulated by means of acetic acid. Practically there is nothing to choose between all these rubbers, and if judiciously used we see no reason at present why mineral acids should not be as satisfactory in results as acetic acid. However, as before stated, it will be better to avoid making this a definite statement until we have seen whether there may be any effect upon the rubber due to a small residual quantity of mineral acid. A word of warning also as to the extremely dangerous nature of strong mineral acids would not be out of place here. The risks of handling these strong acids are, as you probably know, extremely great, amounting almost to a danger to life in the case of inexperienced persons.

Numerous other experiments have been carried out in the laboratory, with coagulants other than acids, with a view to possibly finding some substance which might prove to give superior results to acetic acid. These experiments are still being continued. In the meantime a number of samples have been tested, and the results are given below in a general table which includes also the samples of the dilution experiments and of the coagulation experiments with acids other than acetic acid.

REFERENCES.

N. 27. Sheets coagulated with aluminium sulphate and a preservative.
O. 27. Sheets coagulated with "purub."
P. 27. Sheets and biscuits coagulated with magnesium chloride.
Q. 27. Sheets and biscuits coagulated with calcium chloride and a preservative.
R. 27. Sheets coagulated with magnesium chloride and a preservative.
S. 27. Sheets and biscuits coagulated with calcium chloride and a preservative.
T. 27. Sheets and biscuits coagulated with aluminium sulphate.

W. 27. Very pale sheets, coagulated with sodium chloride and a preservative.

X. 27. Pale sheets, coagulated with potassium hydrogen tartrate and a preservative.

Y. 27. Crêpe sheets, coagulated with potassium hydrogen tartrate and a preservative.

Z. 27. Sheets and biscuits coagulated with magnesium sulphate.

NUMERICAL RESULTS.

	Resiliency.	Resistance to stretching (elasticity).	Recovery (sub-permanent).	Recovery (Admiralty).
S. 20 . .	$51\frac{1}{2}$	102	83·7	84·3
E. 27 . .	51	106	85·3	84·8
F. 27 . .	50	103	84·9	84·5
G. 27 . .	50	103	84·7	84·2
H. 27 . .	$49\frac{1}{2}$	104	84·3	83·9
J. 27 . .	48	97	83·6	84·0
K. 27 . .	49	94	83·5	84·0
L. 27 . .	48	93	83·6	84·1
M. 27 . .	50	92	83·9	84·4
N. 27 . .	50	100	85·6	85·6
O. 27 . .	51	100	83·3	84·3
P. 27 . .	$49\frac{1}{2}$	94	83·7	84·9
Q. 27 . .	$48\frac{1}{2}$	99	83·9	84·4
R. 27 . .	$51\frac{1}{2}$	99	85·0	85·3
S. 27 . .	51	101	84·6	85·1
T. 27 . .	$52\frac{1}{2}$	105	85·7	86·0
U. 27 . .	$47\frac{1}{2}$	89	83·4	85·1
W. 27 . .	$46\frac{1}{2}$	98	84·8	84·8
X. 27 . .	$48\frac{1}{2}$	101	85·7	84·9
Y. 27 . .	$49\frac{1}{2}$	98	85·2	84·8
Z. 27 . .	$50\frac{1}{2}$	97	83·9	85·5

A study of these figures does not reveal any very striking result. As a whole the figures are remarkably alike. The best results were obtained from T. 27 coagulated by means of aluminium sulphate, but the difference between these results and those obtained from the general body of the others or from samples prepared with acetic acid is very slight.

A series of samples was prepared with tartaric acid.

The samples comprised the following :—

Z. 33. Biscuits coagulated with a minimum quantity of tartaric acid; rolled next morning; dark colour.

A. 34. Biscuits coagulated with twice the minimum quantity of tartaric acid; rolled next morning; pale colour.

B. 34. Biscuits coagulated with three times minimum quantity of tartaric acid; rolled next morning; pale colour.

C. 34. Biscuits coagulated with four times minimum quantity of tartaric acid; rolled next morning; pale colour.

D. 34. Biscuits coagulated with a minimum quantity of tartaric acid; rolled after four hours; darkish colour.

E. 34. Biscuits coagulated with twice minimum quantity of tartaric acid; rolled after four hours; pale colour.

F. 34. Biscuits coagulated with three times minimum quantity of tartaric acid; rolled after four hours; pale colour.

G. 34. Ordinary acetic acid crêpe; latex diluted with 15 parts of water.

H. 34. Ordinary acetic acid crêpe; undiluted latex.

E. 31. Standard pale rubber.

NUMERICAL RESULTS.

		Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
Overnight	Z. 33	53½	99	89·2
	A. 34	48½	89	81·9
	B. 34	49½	91	82·8
	C. 34	48½	89	83·4
After four hours	D. 34	55	107	88·2
	E. 34	53	101	86·7
	F. 34	52½	101	86·5
Diluted and undiluted latex	G. 34	52	94	84·9
	H. 34	56½	108	89·5
	Standard E. 31	58½	124	90·8

A glance at the above figures allows of the following inferences being made:—

(*a*) As with acetic acid the quantity of acid has little effect on the quality of the rubber, but generally the larger the proportion the lower the quality.

(*b*) The difference between the samples rolled next morning and those rolled after four hours is in favour of the latter; but the difference is not so marked as in the case of acetic acid coagulation.

(*c*) The rubber from latex diluted with 15 parts of water is markedly inferior to that from undiluted latex. This is in agreement with results obtained from lower dilutions of latex.

(*d*) None of the samples are equal to the Standard Pale crêpe used for comparison.

It will be noticed that in both cases where the minimum of coagulant is used the colour of the rubber is reported as being

darkish; whereas with an increased quantity of coagulant the colour is pale. This is true in the use of almost all coagulants, and formerly advantage of the fact was taken in the preparation of very pale rubbers, when three and four times the necessary quantity of acid was used in order to obtain a pale colour. As shown, this was done at the expense of a slight loss in quality.

The following tests were made upon samples prepared experimentally with various coagulants :—

S. 28. Sheets coagulated with sodium chloride, formic acid, and a preservative (experimental).

V. 28. Sheets prepared with potassium hydrogen tartrate (cream of tartar), formic acid, and a preservative (experimental).

W. 28. Sheets coagulated with calcium chloride (experimental).

NUMERICAL RESULTS.

S. 28	55	96	90·7	94·8
V. 28	49½	92	90·3	94·6
W. 28	49	96	90·7	95·1

All these examples are of the same class as ordinary unsmoked sheet rubbers and present no striking new information.

Samples prepared with various acids and preservatives were tested :—

REFERENCES.

X. 29. Sheet and biscuits: prepared with oxalic acid, carbolic acid, and sodium bisulphite.

Y. 29. Sheet and biscuits: prepared with tartaric acid, carbolic acid, and sodium bisulphite.

Z. 29. Sheet and biscuits: prepared with citric acid, carbolic acid, and sodium bisulphite.

A. 30. Sheet and biscuits: prepared with acetic acid, carbolic acid, and sodium bisulphite.

E. 27. Ordinary crêpe: with acetic acid.

NUMERICAL RESULTS.

	X. 29.	Y. 29.	Z. 29.	A. 30.	E. 27.
Resiliency	58½	61½	58	59½	57
Resistance to stretching	98	116	97	105	101
Recovery (sub-permanent)	91·2	92·4	89·5	91·6	93·1
Recovery (Admiralty)	96·0	97·1	96·0	96·8	96·2

There is very little to choose between the different samples, Y. 29 being slightly the best. All of them are just superior to E. 27, but this should be so, as the latter is only a crêpe rubber.

Results with sulphuric acid.

From previous experimental work it was found that any mineral or organic acid, if used in minimum proportions, will give a rubber of average quality. Acetic acid, however, may be used in excess without doing serious damage to the resulting rubber.

These more recent experiments were carried out with a view to testing the effect of excess of sulphuric acid, various grades of rubber being prepared as it was not felt it would be fair to judge solely from the results obtained from crêpes which in the course of washing would have been quickly rid of excess of acid.

Three series of samples were prepared and tested as follows:—

Sulphuric acid samples, first series; crêpes and biscuits (unsmoked).

Two parallel lots were prepared, the first of which was left standing for three hours only and the other was allowed to remain over-night in contact with the mother-liquor.

M.	Pale crêpe	; minimum quantity of acid	; left 3 hours.
W. 36.	„ „	; twice minimum quantity of acid	; „ over-night.
X. 36.	„ „	; „ „ „ „	; „ 3 hours.
Y. 36.	„ „	; 5 times „ „ „	; „ over-night.
Z. 36.	„ „	; 5 „ „ „ „	; „ 3 hours.
A. 37.	„ „	; 7 „ „ „ „	; „ over-night.
B. 37.	„ „	; 7 „ „ „ „	; „ 3 hours.
C. 37.	Greyish „	; 10 „ „ „ „	; „ over-night.
D. 37.	„ „	; 10 „ „ „ „	; „ 3 hours.
E. 37.	„ „	; 12 „ „ „ „	; „ over-night.
F. 37.	„ „	; 12 „ „ „ „	; „ 3 hours.
G. 37.	Pale biscuits	; 7 „ „ „ „	
E. 31.	Standard Pale crêpe.		

The sample F. 37 prepared with 12 times minimum quantity of sulphuric acid is not included in the following results as it was too poor in quality to stand testing:—

		Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
	M. 3 hours.	57	110	86·3
Twice Minimum	W. 36, 20 „	54	95	86·7
	X. 36, 3 „	55	99	85·8
5 times Minimum	Y. 36, 20 „	$54\frac{1}{2}$	95	82·4
	Z. 36, 3 „	53	92	78·7
7 times Minimum	A. 37, 20 „	52	92	79·6
	B. 37, 3 „	$53\frac{1}{2}$	95	82·1
	G. 37, 3 „ (biscuit)	61	98	81·3
10 times Minimum	C. 37, 20 „	$52\frac{1}{3}$	91	79·3
	D. 37, 3 „	$52\frac{1}{3}$	91	79·0
12 times	E. 37, 20 „	$61\frac{1}{2}$	95	74·8
	E. 31, 20 „ (standard)	$58\frac{1}{2}$	124	90·8

(*a*) It will be seen that all the samples prepared with sulphuric acid are very inferior to the Standard Pale Crêpe prepared with acetic acid. **Comments.**

(*b*) Taking a general line through the results, it may be stated that the order of merit of these samples is directly connected with the quantity of coagulant used. The larger the excess of sulphuric acid the more inferior the rubber.

(*c*) The only apparent exception to this rule is the sample G. 37, but it must be borne in mind that this was a biscuit sample and hence we should have expected it to behave in just the way it has done.

These samples were really duplicates of the unsmoked rubbers, but were smoke-cured. Two parallel lots were prepared, one of which was allowed to remain in contact with the mother-liquor over-night (20 hours), while the other samples were worked up about three hours after coagulation had commenced. **Sulphuric acid, second series; smoked crêpes.**

Samples.

I. 37.	Smoked crêpe	twice minimum sulphuric acid;	20 hours;	smoked 21 days.	
J. 37.	" ;	" " " " ;	3 " ;	" 21 "	
K. 37.	" ;	5 times " " " ;	20 " ;	" 21 "	
L. 37.	" ;	5 " " " " ;	3 " ;	" 23 "	
M. 37.	" ;	7 " " " " ;	20 "	air-dried 21 " / smoked 14 "	
N. 37.	" ;	7 " " " " ;	3 " ;	smoked 21 "	Crêpe strained but not broken.
O. 37.	" ;	10 " " sulphuric acid;	20 hours;	smoked 21 "	
P. 37.	" ;	10 " " " " ;	3 " ;	" 21 "	Crêpe badly strained and broken.
Q. 37.	" ;	12 " " sulphuric acid;	20 hours;	smoked 21 "	
R. 37.	" ;	12 " " " " ;	3 " ;	" 21 "	Crêpe badly strained and broken.

F. 31 Standard smoked sheet.

NUMERICAL RESULTS.

		Resiliency.	Resistance to stretching.	Recovery (sub-permanent).
Twice	I. 37, 20 hours	64·0	125	92·6
Minimum	J. 37, 3 "	65·4	136	93·2
5 times	L. 37, 3 "	60·4	114	88·1
Minimum	K. 37, 20 "	60·2	119	88·5
7 times	M. 37, 20 "	59·4	118	85·7
Minimum	N. 37, 3 "	60·7	121	86·9
10 times	O. 37, 20 "	60·8	117	85·6
Minimum	P. 37, 3 "	60·7	118	87·1
12 times	Q. 37, 20 "	59·8	114	84·4
Minimum	R. 37, 3 "	61·0	118	87·4
Acetic acid	F. 31 (Standard).	65½	140	94·1

These results may be expressed more clearly by taking the total number of marks for each sample in the above table and putting them to comparison, as follows:—

TIME LEFT STANDING.

	20 hours.	3 hours.	Average of foregoing.
Twice minimum sulphuric acid . .	281	294	288
5 times „ „ . .	262	267	265
7 „ „ „ . .	263	268	265
10 „ „ „ . .	262	265	264
12 „ „ „ . .	258	266	262
Average of the above	265	272	269
Standard smoked sheet acetic acid coagulation	299	—	—

A brief consideration of the above results shows that none of the samples approached in quality the standard smoked sheet, and that speaking generally the greater the excess of acid the more inferior the resulting rubber. It will also be noticed that the samples allowed to stand for only three hours proved to be slightly superior to those which remained in contact with the mother-liquor over-night. With excess of this acid this is what one would have been led to expect.

Sulphuric acid; third series (smoked sheets).

SAMPLES.

N. 36 Smoked sheet; twice minimum quantity; smoked 21 days.
O. 36 „ ; 5 times „ „ „ 26 „
Q. 36 „ ; 7 „ „ „ „ 26 „
R. 36 „ ; 10 „ „ „ „ 21 „
S. 36 „ ; 12 „ „ „ „ 21 „
P. 36 „ ; 7 „ „ „ „ 21 „
From new latex; first period of tapping trees.
F. 31 Standard smoked sheet (acetic acid).

NUMERICAL RESULTS.

	N. 36.	O. 36.	Q. 36.	R. 36.	S. 36.	P. 36.	F. 31.
Resiliency	62	62	59	59	59	61	65½
Resistance to stretching .	134	124	121	120	117	129	140
Recovery (sub-permanent) .	91·5	90·0	87·6	87·0	85·6	88·2	94·1

Here again one sees that, taking a line through the samples, the quality is lowered as the quantity of coagulant increases. The results shown by P. 36 are not in line because this rubber was

prepared from another latex. None of the samples were equal to the standard acetic acid sheet.

Effect of mineral acids other than sulphuric acids.

It was desired to study the effects produced upon rubber by the use of nitric and hydrochloric acids. Samples were prepared and tested as below. The sulphuric acid samples are again included for the sake of comparison.

A. 40	Pale crêpe	: minimum quantity	: ordinary working	nitric acid.
B. 40	„	: twice minimum quantity	: „ „	
D. 40	„	: 8 times „ „	: worked in ½ hour	
E. 40	Sheet (pale)	: 2½ „ „ „	: ordinary working	hydrochloric acid.
F. 40	Pale crêpe	: minimum quantity	: „ „	
G. 40	„	: twice minimum quantity	: „ „	
H. 40	„	: minimum quantity	: „ „	sulphuric acid.
W. 40	„	: „ „	: after 3 hours	
E. 31	Standard pale crêpe.			

NUMERICAL RESULTS.

	Nitric acid.			Hydrochloric acid.			Sulphuric acid.		
	A. 40.	B. 40.	D. 40.	Sheet. E. 40.	F. 40.	G. 40.	H. 40.	W. 40.	E. 31.
Resiliency	57·6	57·2	54·5	65·4	57·8	54·8	55·9	54·3	58·5
Resistance to stretching .	100·7	104·3	112·7	121·5	113·0	114·0	115·8	113·8	124·0
Recovery (sub-permanent) .	75·7	81·7	78·8	91·3	87·9	84·9	85·6	83·4	90·8

The following conclusions are evident from a study of the figures:—

(*a*) No sample except E. 40 is equal or superior to the standard pale crêpe. But that sample, although a poor specimen, was in sheet form.

(*b*) All the samples prepared with nitric acid are much inferior to standard pale crêpe.

(*c*) All the crêpe samples prepared with hydrochloric and sulphuric acids are similarly inferior.

FORMALIN A PRESERVATIVE AND ALSO A COAGULANT.

The use of formalin as an agent to retard coagulation in latex is so well known that it must come as a matter of surprise to be told that it is also a coagulant. In the course of experimental work, the writer was using formalin as an intended

preservative, but owing to a mistake the strong solution was used instead of a 1 per cent. solution. The following morning on looking casually at the experiment it was thought that the latex was still liquid; but a more careful examination showed that the apparent liquid was composed of numberless small particles of rubber in suspension. On filtering under pressure this apparent latex yielded a mass of small clots and an almost clear liquid.

These results were so interesting that the experiment was repeated on a large scale and the rubber obtained by pressing the mass of tiny clots into a solid form was sent home for testing.

Below, the figures yielded in these tests are reproduced in comparison with an ordinary pale crêpe and our standard pale crêpe.

1. Crêpe from rubber coagulated with formalin.
2. Ordinary pale crêpe; minimum of acetic acid.
3. Standard pale crêpe.

NUMERICAL RESULTS.

	1	2	3
Resiliency	70·3	54·3	58·5
Resistance to stretching . . .	134·0	101·4	124·0
Recovery (sub-permanent) . . .	93·4	83·2	90·8

It will be seen that the rubber coagulated with formalin is very much superior to the standard pale crêpe, and that the ordinary pale crêpe is very much inferior. The results given by the formalin-coagulated rubber are so high as to make it comparable even with smoked-sheet rubber.

In spite of this formalin is not to be recommended as a coagulant as the process would entail much labour and would otherwise prove expensive.

The results of the experiment are, however, worthy of note as being interesting from a scientific point of view.

CHAPTER XX

VARIOUS

ONE of the stock arguments of those prejudiced against plantation rubbers is that connected with the use and abuse of acid coagulants. It seems to be imagined that acetic acid is used with a reckless disregard of consequences and of what is necessary for effective coagulation. That there may have been some slight justification for such a belief in the past is perhaps true, but even only from considerations of economy we might now be credited with a desire to restrict the quantity of coagulant to a minimum. It is pointed out, of course, that no acid is used in preparing Brazilian Fine Hard, but the fact that the smoke employed contains an appreciable quantity of acid is apparently forgotten. It might be pointed out that plantation crêpes are shipped in a clean and well-washed condition, so that had even an excess of acid been employed in coagulation one would not expect to find more than the merest trace of residual acid. In the course of experimental work it was decided to test the acidities of scores of samples in comparison with Fine Hard. The method of extracting the residual acid was by shredding the rubber sample and placing it in a known quantity of water in a well-stoppered flask for fourteen days. The solution was then filtered off and made up with washings to 100 ccs. Phenolphthalein was used as an indicator. ACIDITY OF PLANTATION RUBBERS.

A few results are given with the idea of showing how plantation samples and experimental samples compare in residual acidity with Hard Para. Peculiarly enough those plantation rubbers in the preparation of which acid has been used prove to have the least residual acidity. This is most probably due to the thorough washing which first grade crêpes receive.

At first sight crêpes from coagulated lump and tree-scrap would be expected to be less acid than acetic acid coagulated rubber; but it must be remembered that when latex coagulates naturally coagulation is still the effect of an acid, in these cases

engendered in the latex itself. Thus it is possible, and in point of fact is often the case, that a naturally coagulated rubber is equally if not more strongly acid than a clean crêpe which has been prepared from rubber coagulated with acid.

Below are given the results obtained from typical samples :—

		Percentage Acidity (calculated on weight of rubber).		
1	Hard Para (crêped) . .	0·24	per cent.	
2	Pale crêpe	0·055	"	
3	"	0·045	"	
4	"	0·044	"	
5	"	0·053	"	
6	"	0·061	"	
7	" (thick) . . .	0·040	"	
8	"	0·035	"	(worked in three hours after coagulation.)
9	Cup-washings crêpe . .	0·071	"	
10	"	0·059	"	
11	Lump crêpe. . . .	0·074	"	(naturally coagulated.)
12	"	0·063	"	
13	Scrap crêpe. . . .	0·118	"	(tree-scrap.)
14	"	0·089	"	(")
15	Thick pale crêpe . . .	0·087	"	
16	"	0·074	"	
17	Thick lump crêpe . .	0·072	"	
18	Earth-rubber crêpe . .	0·145	"	

These figures were obtained from estate samples, and while the results are not uniform they give one a good idea of the residual acidities in comparison with crêpe made from Hard Para rubber. It will be noticed that while the highest figure obtained from plantation samples was that from an earth-rubber naturally coagulated, it does not approach in acidity the Hard Para sample; and further, that the pale crêpes prepared from acid-coagulated rubbers show only one-fifth or one-sixth the acidity of Hard Para. Comparing the other grades of naturally coagulated rubbers with pale crêpes it will be seen that their acidity is apparently sometimes less, sometimes equal to, and sometimes greater than that of the pale rubbers.

Residual acidity of un-smoked sheets.

In considering the residual acidity of pale sheets we may start with the assumption that it should be greater than that of pale crêpes seeing that sheet rubber receives less washing. In the majority of cases this assumption is justified by results, but if the sheet rubber is properly rolled the difference should not be great. Samples were prepared in the laboratory, one series being made in small biscuit form which received much

hand-rolling, and the other series in ordinary sheet form. In both cases acid was used in solutions of different strengths.

Pale sheet. (Minimum acid.)	Percentage. Acidity.	Pale sheet. (Minimum acid.)	Percentage. Acidity.
1 per cent. solution	0·069 per cent.	1 per cent. solution	0·189
1·3 „	0·074 „	2 „	0·189
2 „	0·077 „	3 „	0·187
2·5 „	0·068 „	4 „	0·184
3·3 „	0·055 „	5 „	0·169
10 „	0·048 „	10 „	0·146
20 „	0·039 „	20 „	0·121

The samples in the left-hand column were the thin biscuits which received a great deal of hand rolling. Whether it is really so we cannot say at present, but it would appear as if the extra rolling had some connection with the decreased acidity as compared with the ordinary sheet samples. It would also appear from these results, curiously enough, that the acidity diminished as the strength (but not the quantity) of the acid solution increased. It will be shown later that when smoked samples were tested, the reverse was apparently the case, so that unfortunately no deduction as to this fact can be made at present.

It will be noted, however, that no sample approaches in acidity that of the Hard Para crêpe given at the top of the crêpe section.

A series of crêpes were made using twice the necessary quantity of acid in solutions of varying strengths. The results are given in the first columns below, and in the second column will be found results obtained from estate samples of smoked crêpes. Acidity of smoked crêpes.

Smoked crêpes. (Twice minimum acid.)	Percentage. Acidity.	Estate smoked crêpes.	Percentage. Acidity.
1 per cent. solution	0·088 per cent.	(*a*)	0·16 per cent.
2 „	0·139 „	(*b*)	0·15 „
{ 4 „	0·137 „	(*c*)	0·18 „
{ 4 „	0·148 „	(*d*)	0·17 „
7·5 „	0·153 „	(*e*)	0·23 „
10 „	0·236 „	(*f*) [5 wks.] . .	0·24 „

In the case of the experimental samples all were for a uniform period of 21 days, but the estate samples were smoked for varying periods so that no comparison between these can be made. It may be remembered that the acidity of the Hard Para crêpe was given as 0·24 per cent., and it will be apparent that some plantation smoked crêpes may equal this.

The point to be borne in mind, however, is that part of this acidity (and probably the greater part) must be due to the process of smoking.

Acidity of sheet.

In comparing the residual acidity of plantation smoked sheet with fine Hard Para, both samples were not crêped but were cut up into fine shreds.

A series of experimental samples was prepared with the minimum quantity of acetic acid, but in solutions of varying strength. The results from these are given below in the first column, while in the second column will be found the figures obtained from typical estate samples.

Residual acidity, shredded Fine Hard Para, 0·31 per cent.

Experimental smoked sheets.	Percentage. Acidity.	Estate smoked sheets.	Percentage. Acidity.
1 per cent. solution	0·081	(*a*)	0·178
2 "	0·083	(*b*)	0·194
3 "	0·096	(*c*)	0·180
4 "	0·132	(*d*)	0·163
5 "	0·158	(*e*)	0·130
7·5 "	0·156	(*f*)	0·25
10 "	0·204	(*g*)	0·098
20 "	0·220	(*h*)	0·27
All samples smoked 21 days.		(*j*)	0·32

The periods of smoking and strengths of acid solutions vary on each estate. No comparisons can therefore be made.

Numerous other results could be given from estate samples, but sufficient are presented above to give a very fair idea of how the residual acidities of smoked sheet vary. Some are quite equal to that of Hard Para sample, while others give only half the acidity. It will be observed that none of the experimental samples prepared with varying proportions of minimum acid give very high figures in spite of the fact that they had received smoke-curing for 21 days.

It has already been pointed out in a previous paragraph that in the case of experimentally prepared pale sheets the residual acidity apparently decreases as the strength of the acid solution increases; but judging from the foregoing results and those obtained in the smoked crêpe section, the reverse is apparently the case with smoke-cured rubbers. It will be seen that as the strength of solution increases in the above table so the residual acidity is increased. These contradictory results are rather

puzzling, and further work is necessary before anything definite can be advanced.

Enough has now been written to show that there is no foundation for the legend of over-acidity in plantation rubbers. It has been shown by the actual results obtained in comparison with Hard Para that plantation rubber is an extra-pure product, and that the only grade which in the ordinary way equals Fine Hard Para in acidity is plantation smoke-cured sheet. Even so, the acidity is so slight that it would be idle to pretend that it is a factor of such immense importance as would appear from the rash statements made. In the past no point was too small to seize upon as an argument against the quality of plantation rubber: but gradually these assertions are being disproved, and we may now claim that one grade (smoke-cured sheet) can be prepared equal in quality, if not superior, to Fine Hard Para in all physical tests and chemical purity. The fine pale crêpes naturally cannot approach these smoke-cured rubbers in strength, but nevertheless they command a position in the market by their purity and general cleanliness.

THE GRADING OF PLANTATION RUBBER.

The question of standardising plantation rubber is one which has occupied the attention of many. While in the main opinion is in favour of attempting to arrive at a standard product, there are some who hold that standardisation in this direction has no possibility of becoming an established fact for many years.

Meanwhile opinion is growing in favour of proceeding along the line of reducing the number of plantation grades to a minimum. At present much confusion exists in all directions. Some estates make up tree-scrap and earth-scrap together; one estate puts tree-scrap, earth-scrap, and bark-shavings into one uniform crêpe; most other estates have three separate scrap grades, tree-scrap, earth-scrap, and bark-shavings scrap. Do coagulated-lump rubber and cup-washings rubber belong to the scrap grades? This question has been settled by one company in the affirmative; and, as far as our information goes, the Government scale of duty coincides with this opinion. There is a movement on foot at present to try to restrict plantation rubber to three grades:—

1. *First quality latex: i.e.* crêpe made from the true coagulum obtained from the coagulation of strained latex.

It must be very evident that unless buyers are willing to purchase mixed lots varying in shade of colour, some latitude must be allowed sorters in the way of making sub-divisions to this heading. It is suggested that three or four sections would

be sufficient and would embrace approximately all defined shades of colour.

2. *Scrap No.* 1.—In this it is proposed to include cup-coagulated lumps, coagulated lumps from transport vessels, cup-washings, and tree-scrap.

3. *Scrap* 2.—This grade would include the remaining lower grades, viz. bark-shavings scrap and earth-rubber scrap.

Fewer grades not necessarily simplification.

However desirable it may be to diminish the number of grades, it must be pointed out that diminution and simplification are not synonymous terms in this question; rather the reverse. Objection must be lodged against the inclusion of self-coagulated lump rubber and cup-washings rubber with tree-scrap. True, tree-scrap is also a self-coagulated rubber; but unless it is picked over carefully by hand it should not be included with the other naturally coagulated rubbers, for obvious reasons.

Again, up to the present time it has been customary to imagine that nothing could be prepared from coagulated lump rubber and cup-washings rubber but a dirty, streaky crêpe. In the laboratory at present are samples of crêpe made from these particular rubbers which, except for the desired paleness, are in every way equal to first-grade latex crêpes. They are clean, uniform in colour and texture, and show no signs of streakiness. In every way they deserve to be included under Division I, and have no place amongst scrap rubbers. If the same methods of preparation were more generally used we should see a great improvement in lump-rubber crêpes; and as this grade approaches nearly to the Brazilian naturally coagulated rubber, it is suggested that this grade of crêpe be known as "Virgin-rubber" crêpes.

A further point worth considering is the desirability of mixing earth-rubber scrap and bark-shavings scrap. It is well known that on estates where the earth-rubber is only brought in at lengthy intervals, say of a week, the resulting crêpe is sometimes very tacky. This is only natural, and is due to the prolonged exposure to the sun's rays. With the improved machinery now at our disposal, and with the increasing attention which will be given to the lower grades in the future, it is possible to prepare crêpe from bark-shavings free from bark and of quite a good colour. Such a crêpe is being made on several estates even now. The specimens are so good that even expert planters have been misled in classifying them. Does it not seem a pity, therefore, that these crêpes should be mixed with possible tacky earth-rubbers?

Taking the foregoing arguments into full consideration, it would seem that, strictly speaking, the number of grades cannot be reduced to less than four at present without producing some amount of confusion. For the sake of causing discussion on the subject and so focussing attention on this question of grading, we would venture to propose the following scheme of classification, which we submit would meet present and, possibly, future contingencies:—

1. *First quality latex*, with three or four sub-divisions to embrace various decided shades of colour. All crêpes and sheets to be prepared from coagulum obtained by treating strained latex with a coagulant.

2. *Virgin-rubber crêpe*, with two subdivisions:—

(*a*) Uniform clean crêpes free from dark streaks.

(*b*) Clean crêpes streaked with dark oxidised surface rubber.

All these would be prepared from naturally-coagulated rubber (including cup-coagulations and lump rubber) and coagulated cup-washings.

3. *No.* 1 *scrap crêpes*, including tree-scrap crêpes and bark-shavings crêpe.

4. *No.* 2 *scrap crêpes*: from scrap rubber obtained from the ground near the bases of the trunks of trees.

Finally, and apropos of the subject, one planter proposes to solve the question of classifying lower grades of rubber by putting tree-scrap, bark-shavings, and earth rubber into a "Universal Washer" and so making one uniform grade There is certainly something to be said for the proposition, but it would appear at present to be a rather heroic measure for which the consumer is not yet ready. It is, however, well worth consideration in the near future.

THE USE OF COPPER SALTS IN SPRAYING MIXTURES.

Requests for advice in the matter of using spraying mixtures which contain salts of copper have reached the writer on several occasions from estates on which these mixtures were recommended for the treatment of "pink disease" (presumably Corticium Javanicum). This disease has been confined in the main to the northern portion of the peninsula up to the present, but recently it seems to be advancing south. As it is the natural occurrence for such diseases to spread unless taken in hand at once, a few remarks in these pages may probably be in season.

Let it be noted, therefore, that *the use of spraying mixtures*

Not recommended. *containing salts of copper cannot be recommended for rubber trees which are in bearing.* For spraying nurseries and young trees there can be no objection to any of these mixtures.

May cause tackiness in the rubber. The unfortunate circumstance generally is that managers cannot afford to rest the trees which need spraying. Could they rest these trees for a month or so almost any spraying mixture could be used with benefit. But managers are warned that tapping the affected trees while they are under treatment with spraying mixtures containing salts of copper is a policy which may bring them much trouble in connection with the quality of the rubber.

It has previously been pointed out that copper and its salts are fatal to rubber, causing tackiness wherever they come in contact with it.

Other harmless mixtures available. Moreover, there can be no legitimate excuse for the use of spraying mixtures containing copper salts on trees in bearing, since there are other mixtures equally efficacious and quite harmless. A prescription for such a mixture will be given later.

THE CORRECT SPRAYING MIXTURE FOR TREES IN BEARING. The correct mixture to use for trees in tapping is a *Lime-sulphur* wash. The only point to remember in the use of this wash is that *ordinary copper sprayers must not be used.* Special "Vermorel" sprayers, tin-lined, or otherwise proofed, are made for this purpose.

There are many and varied formulæ for making Lime-sulphur washes, all of which are more or less efficient. Quite a considerable amount of research has been carried out upon the efficacy of varying Lime-sulphur washes, especially in the United States of America, where immense quantities of this wash are used for spraying against fungi and scale insects. As a result it has been found that the most efficient wash is the one made with the greatest amount of care in boiling. Below are given two prescriptions, the first of which is far more efficacious and economical.

1. LIME-SULPHUR WASH for fungi and scale.

Hot Preparation.

Pure quicklime	40 lbs.
High-grade, finely-divided sulphur .	80 ,,
Water	50 gallons

N.B.—(*a*) Air-slaked lime should *on no account be used.*

(*b*) Both lime and sulphur should be as finely powdered as possible.

Mode of Preparation:

1. Place lime in a boiler (not of copper), and add enough water to cover.
2. Gradually add sulphur, and light fire beneath boiler. The mixture soon boils.
3. Stir at short intervals, and take care that the volume of the solution during boiling is maintained by adding more water.
4. Boil for 4 or 5 hours when it should be found that there is practically no sediment on cooling.

The mixture should be as fresh as possible for spraying.

---

2. Lime-sulphur wash: not so efficient as No. 1.

Cold Preparation.

Good quicklime	25 lbs.
Good powdered sulphur . .	30 ,,
Water	50 gallons

Mode of Preparation:

1. Place lime in a barrel and add enough water to cover. While the lime is slaking add the sulphur through a sieve.
2. Stir constantly and add water as needed to make a thick paste at first, and then gradually make a thin paste.
3. When the lime is well slaked, add water to cool the mixture. Strain carefully and dilute up to 50 gallons.

N.B.—Use when fresh and spray from vessel coated on the interior surface with tin.

For spraying nurseries and young trees against attacks of fungi and scale, preparations containing copper salts may be used. Of these the best is Bordeaux mixture which is most efficient if compounded in the following manner.

Bordeaux mixture, for fungi in nurseries and young trees.

Copper sulphate	3 lbs.
Unslaked lime (quicklime) .	2 ,,
Water	20 gallons

Mode of Preparation:

1. Slake the lime in a barrel and dilute up to 10 gallons.
2. Place the copper sulphate in a sack and suspend it in a barrel containing 10 gallons of water.

3. Before mixing stir both liquids very thoroughly.
4. Dip a bucket in each solution and pour the two liquids together into the sprayer, at the same time stirring vigorously.
5. Test for excess of copper in the mixture by inserting a clean steel blade for one or two minutes. If copper is deposited on the steel more lime solution must be added to the mixture.

N.B.—The mixture should be made up as required and should be used at once.

Though not having the same immediate interest at present, it may be useful for managers to have other prescriptions for spraying mixtures for future reference. The mixtures as given are for use against scale and biting insects which attack the leaves of young trees and plants in nurseries or gardens.

KEROSENE EMULSION: for scales and other leaf-sucking insects.

Kerosene	$3\frac{1}{2}$ gallons
Hard soap	1 lb.
Water	2 gallons

Mode of Preparation:

(*a*) Dissolve the soap (shredded) in boiling water, and while hot add the kerosene gradually. Stir steadily for 15 to 20 minutes with a churning motion.

(*b*) Dilute with sufficient water to make up 10 gallons. This is the stock emulsion.

(*c*) For spraying, dilute the stock solution at the rate of 1 gallon of emulsion to 5 gallons of water.

ARSENATE OF LEAD solution: for leaf-biting insects.

Arsenate of Lead	$1\frac{1}{2}$ lbs.
Good quicklime	$1\frac{1}{2}$ lbs.
Water	20 gallons

Mode of Preparation:

(*a*) Slake the lime in a wooden vessel; dilute to 20 gallons and dissolve the arsenate of lead in the solution.

(*b*) Keep the mixture constantly agitated.

N.B.—This is one of the most effective mixtures for treating leaf-biting insects.

"PARIS GREEN" solution; for leaf-biting insects.

Paris Green	. . . .	4 ozs.
Quicklime	. . . .	$1\frac{1}{4}$ lbs.
Water	. . . . .	20 gallons

Mode of Preparation:

(*a*) Place lime in a wooden vessel and slake. Dilute to 20 gallons and add Paris Green with stirring.

(*b*) "London Purple" may be used instead of Paris Green and in the same proportions.

(*c*) Both have a tendency to settle, and the liquid must be constantly agitated.

PARIS GREEN: administered in solid form.

Paris Green	. . . . .	1 oz.
Powdered *air-slaked* lime	. .	$2\frac{1}{2}$ lbs.

Mode of Preparation:

(*a*) Mix the two in fine powder.

(*b*) Place mixture in coarse cotton bag and shake over the plants, preferably in the early morning while the plants are wet.

THE PACKING OF RUBBER.

Complaints of the condition in which plantation rubber reaches consumers are common, in spite of the precautions taken by all good estates. It is now acknowledged that in a large number of cases the faults complained of could not be attributed to neglect on the part of the original shippers. This was evident from the fact that rubber reached manufacturers in cases other than those in which it was originally shipped from the East. If rubber is thus to be repacked in rough cases it is very unfair to the estates. At the same time, it must be acknowledged that gross negligence is exhibited in the employment of packing cases of which it might be said that the only merit is cheapness. These cases are often of rough timber, which splinters easily, and are so constructed that the case collapses if a heavy weight be superimposed. It should be part of a manager's education to follow his cases of rubber from the time they leave the factory until they are placed in the hold of the steamer. One might easily guarantee that much light would be shed upon the origin of the continual complaints from brokers. The writer has seen on the wharves of local ports cases of rubber smashed

and splintered before entering the ship's hold. Corners are sometimes knocked off, and a gap made sufficiently large to allow of two hands being inserted. Attempts are made to cooper up these damaged cases, but it must be obvious that the condition of the boxes must be very bad by the time the rubber reaches London Docks. Of all the observed packing cases, those which suffer least from rough usage are the three-ply wood "Venesta" cases. Even these, however, are not perfect, as the interior battens are of soft wood, which splinters easily. Further, the present mode of construction, with battens fastened to the interior top of the sides, makes it practically impossible to remove rubber from the case without damage to it. It would not appear to be a very difficult matter for those in the business to evolve a case of three-ply wood which would obviate this difficulty. Probably also the best form of packing would include a lining of heavy oiled-paper so as to exclude any possible splinters.

Another aspect of the subject of packing does not refer so much to containing cases as to discrimination in the actual packing of rubber of varying shades. We are quite aware that too much importance is attached by some to the question of slight differences in colour, and that the quality certainly does not vary according to shade of colour; but at the same time planters must be prepared to supply the market requirements if good prices are to be obtained. The recent decision of one large firm of agents that the person responsible for superintending the actual packing of rubber shall sign a declaration for each shipment is a step in the right direction. Too often one sees in a consignment of first-grade crêpe rubber as many as four or five shades of colour in one box. At the present time, and since the introduction of sodium bisulphite, there should be no such large variety of shades of colour. To allow these to continue to occur, and then to pack without adequate sorting, amounts to gross negligence, which should not be tolerated under European supervision.

CHAPTER XXI

CULTIVATION OF SOILS, ETC.

It is rather unfortunate in some respects that comparisons are unconsciously made in some quarters between an old-established industry like tea-planting and the newer industry of rubber-growing. This must necessarily have happened, since the two industries were forced into comparison in Ceylon. In the control of rubber-growing in the Malay peninsula opinion has been and is largely influenced by men whose experience is more intimately connected with the tea industry. Hence one finds parallels being instituted between the two industries when the necessity for such comparisons does not really exist. It is inevitable that deductions drawn from experience in tea-growing should be applied to rubber-growing, and not always wisely. For example, of late there has been quite a decided movement of opinion in favour of introducing artificial manures into rubber-growing in the Malay peninsula. The matter has been pressed chiefly by Home Authorities, who have been influenced most probably by the results of manuring and general cultivation in Ceylon, where such a course has been found necessary in a large number of cases. It should not be forgotten, however, that in the majority of such cases the land had been under previous cultivation with crops other than rubber; the soil had become partially exhausted, and the necessity for manuring may have become urgent. If the instances could be investigated, it would possibly be found that the soil had been under cultivation with tea, or that the decision to manure was based on experience of what was necessary in tea-growing. It is known that in tea-growing constant cultivation and manuring soon become necessary, but it is not recognised that the growth of rubber trees (Hevea Brasiliensis) takes exceedingly little plant food from the soil, and is in all probability much less exacting than tea.

CULTIVATION.

In this connection also it must be remembered that Malayan plantations on the whole are quite recent growths on extremely

rich virgin lands. This is a consideration which should weigh heavily in any discussion of the subject. Our plantations are comparatively young, and it is quite improbable in the vast majority of cases that the potential food supply in the soil has been more than lightly utilised by the trees as yet. This point is one of great importance, and does not seem to be quite fully appreciated. Some people may have formed imaginary views of the soil becoming more and more depleted each year, so that in the course of a few years no nutriment remains. Such ideas are extremely wide of the mark, as the growth of Hevea Braziliensis makes comparatively small demand upon the soil in the case of virgin lands. On some of our older plantations the conditions may have been more strenuous, possibly, and it may be necessary to discover some means of rendering available the food material which is at present locked up in the soil. That it is there in an unavailable form is undoubted, but unless means are employed for rendering the food material available to plant-life, it may be regarded as non-existent.

In the light of the present trend of opinion it may seem a bold statement, but the writer is strongly of opinion that general manuring (in the case of using artificial or chemical manures) is not yet required. It is not intended to imply that the use of manures may not be necessary at a later stage, but that it would at present be almost a waste of money to put manures into the soil until we have done our best to convert the insoluble reserves of the soil into available plant food. While deprecating the use of chemical manures at present generally, there is no reason why experimental manuring should not be carried out on soils now known to be deficient in quality, so that knowledge may be acquired against the time when manuring will have become generally necessary. To be successful, however, and to obtain results upon which reliance may be placed, it will be necessary to plan experiments carefully. Thus, it would be necessary in planning experiments to make a careful selection of land of suitable area, uniform character, and having trees of uniform growth. The area must then be divided up into the requisite number of plots, divided from each other by deep drains. The size of the plots must be determined by the available area and the number of experiments to be carried out, but for preference they should not be less than an acre in extent.

A simple scheme such as the following might be commenced on a number of estates:—

Plot 1. Check plot: to remain as hitherto.
,, 2. Digging or forking alone.
,, 3. Broadcast liming and forking.
,, 4. Broadcast liming and digging.
,, 5. Manuring and digging. As most soils in the Malay peninsula are deficient in lime, and possibly potash, the manure should contain both of these substances at least.
,, 6. Check: to remain as hitherto.

The experiments may be allowed to run as long as possible and the results may be measured either in yields of rubber, or increase of girth of trees, or both. It would probably be advanced that the keeping of an account of the yields from such small areas would entail a great deal of trouble, and probably most people would incline to the recording of increases of girth as being much simpler, and demanding much less trouble. It might be pointed out that the value of the results of experiments is in proportion to the trouble and labour expended, and that therefore a record of the yields per tapping in each area (in bearing) should be kept.

In any case it should be incumbent upon managers of all older estates to work out the effect of efficient cultivation of the soil on their estates. On a few estates where the soil has been cultivated the results are so distinctly encouraging, both with regard to the yield of latex and to the general growth of the trees, that no manager who meditates putting labour into the soil need have misgivings as to whether the return will be profitable or otherwise. The only question needing consideration is the one of available funds for work which proves a sound investment.

Undoubtedly the first care of managers of estates which have been in the producing stage for several years should be to have the soil turned at regular intervals. By this means the soil is aerated; aeration of soil is one of the elementary principles of agriculture. If carried out properly in Malaya it should be necessary to turn up the soil to the depth of at least six inches either with a fork or a changkol. As far as experience goes to show no great stress need be laid upon the severing of the smaller parts of lateral roots; but it is easy to see that on flat peaty lands where the laterals have risen as near the surface as possible more damage would be done than in the case of hill soils. Neither would it be necessary to carry the digging or forking

close to the bases of the trees, as the feeding rootlets lie much farther away. On some estates the digging is effected in wide strips between the trees in both directions of planting measurements. This has been found to be quite successful, but in younger fields there would appear to be no reason why the whole of the soil area should not be treated if necessary.

Malayan soils deficient in lime.

Certainly to the older estates one strongly recommends that soil cultivation be taken up at once, and that this digging over of the soil be accompanied by lime treatment. There cannot be much doubt that in the very great majority of cases Malayan soils are deficient in lime, and it is only by the addition of lime to the soil that food material at present locked up may be made available to plant life. Of all the operations of agriculture the practice of liming or chalking the soil is one of the oldest.

Distinction between free and combined lime.

Several common manures contain lime, but a clear distinction must be drawn between free lime as it exists in quick-lime (unslaked lime) or slaked lime, and lime combined with an acid as in bones, where it is combined with phosphoric acid, or in gypsum, where it is combined with sulphuric acid.

Sour or acid soils.

It will have been within the knowledge of all that at some time or another the expression has been heard from a planter that the soil has become "sour." There exists no such excellent remedy for this sourness of soil as lime. What is necessary for the soil, however, is not merely the chemical substance lime (or calcium) but a *base*, i.e. something capable of combining with the acids which are naturally or artificially produced in soils. The desired base is to be found in quicklime or in slaked lime.

Acid manures not suitable for sour soils.

Chalk and all natural limestones contain lime combined with carbonic acid, which is so weak an acid that it is easily displaced, and does not interfere with the basic properties of the lime; whereas in bones or gypsum the lime is already completely saturated with strong acids, and in superphosphate there is even an excess of acid which demands more lime from the soil to neutralize it.

Quicklime and slaked lime when applied to the soil quickly revert to the form of carbonate of lime, or chalk, in which they existed before they were burnt in the kiln; and it is this substance, carbonate of lime, that is denoted when reference is made to "lime" in the soil. The superiority of burnt lime over chalk or natural limestones for application to the soil lies simply in the fact that it falls easily into a state of fine division. In this condition some of it passes into solution; it is thus more easily

disseminated throughout the soil and acts with greater rapidity and in smaller quantities.

Returning, however, to the point in question, it should be understood that, using the word lime in the sense given above, only the following substances contain the lime spoken of:— Free lime sub-stances.

Freshly burnt lime (quicklime),
Slaked lime,
Chalk,
Limestones,
Marl,
Basic superphosphate,
Basic slag.

All the foregoing substances contain lime in the form of a base capable of neutralising acids.

In the following substances the lime is already combined with acids, and is no longer capable of acting as a base:— Lime in a combined state.

Bones,
Superphosphate,
Gypsum.

As already pointed out, in superphosphate there is an excess of acid which demands a further quantity of lime to neutralise it. From this it would be apparent that *the use of superphosphate (acid) manures should be limited to soils which are not deficient in lime*, or in other words superphosphate should not be used on average plantation soils in Malaya until the soils have been well treated with lime perhaps several times.

Besides its indirect value in neutralising acidity of soil, lime has several other uses, all of which are of great importance to the planter. These may be given as follows:— THE USES OF LIME.

(1) *Lime improves the nature of the soil* by coagulating the finest particles of clay and rendering the soil more open and friable. Drainage then goes on more readily, and the land is more easily worked to a good tilth. It is difficult to exaggerate the value of this action of lime on heavy and wet soils. Those desirous of securing a good seedbed in wet and heavy soils can test this fact easily by mixing soil and lime. It will be found that the seed bed will be ready and suitable while the remainder of the land is still heavy and wet. It should not be forgotten also in this connection that the character and quantity of the crop may depend as much on securing a good tilth as upon manuring.

(2) *Lime is an essential plant food*, and without it soils cannot

produce their best crops. Soils are generally considered to be deficient in lime when they contain 0·5 to 1 per cent. This, however, must not be too strictly applied to plantation soils, for it is found that soils containing a considerable amount of organic matter may show a higher content of lime than that mentioned and yet may be deficient in lime. In other words, more lime may be applied to rich organic soils with great advantage.

(3) *The insoluble reserves of nitrogenous and potash material* in the soil are brought into action and rendered available for the plant by the presence of lime. For this reason lime should be freely used on older estates where a large quantity of plant nutriment is locked up in the soil.

(4) *It appears to be well established* that the soil organism (Azoto bacter) which fixes nitrogen without the aid of leguminous plants and is probably a great factor in the fertility of tropical soils cannot develop properly unless a good supply of carbonate of lime is present. This organism should flourish in our soils; but, as already pointed out, most plantation soils are deficient in lime, and hence we do not derive the maximum effect in nitrogen fixation.

(5) Lime in one form or another is quite a good remedy for several root diseases and the presence of it in the soil may prove very beneficial in warding off incipient disease.

Summing up it may be said that:—

(*a*) Every form of alkaline lime improves the mechanical condition of the soil.

(*b*) The presence of the lime promotes oxidation of nitrogenous reserves.

(*c*) Lime brings the soil potash into solution.

(*d*) It helps to neutralise and render harmless the organic acids of soils which are rich in humus. In Malaya we are at the beginning of a movement of opinion which recognises that we cannot take from the soil indefinitely without attempting to replace some of the materials already taken from the soil. In point of fact we have not yet arrived at the stage of having availed ourselves of the plant food in the soil, and it behoves us to take advantage of the provision of Nature with an eye also upon future developments.

Influence of manures upon lime in the soil.

In view of the fact that several estates have been advised by their Home authorities to commence the use of artificial manures it would not be amiss at this stage to point out the influence which manures have upon the lime content of the soil. It may

be accepted as an axiom that the various classes of manures have a direct bearing upon the rate at which lime is washed out of the soil. This question has been investigated at the Rothamstead Experimental Station in England. The results of those investigations may be given briefly as follows:—

1. Superphosphate, sulphate of potash, kainit and kindred manures do not increase the loss to any appreciable extent.

2. Farmyard manure, and probably all organic manures, diminish the average loss of carbonate of lime.

3. Nitrate of soda also diminishes the average loss.

4. Sulphate of ammonia *increases* the loss, removing about half its weight of lime or nearly its weight of chalk. It would not be wise, therefore, to use this chemical upon a soil already deficient in lime.

In grass-covered lands lime sinks in the soil from purely mechanical reasons; but in arable land this sinking is less marked. Nevertheless, the lime is subject to a greater wastage by solution in the rain-water percolating through the soil. For this reason the amount of lime used in new clearings where the soil is heavy should be greater in comparison with fields where the shade is more dense.

In nature lime generally occurs as carbonate in the form of chalk, limestone, marble, marl, and other substances. Perhaps one-sixth of the rocks composing the earth's crust consists of this material. Classes of lime.

Substances containing lime which are of any importance in agriculture may be tabulated as follows:—

1. *Bases:* capable of neutralising acids:

Quicklime	Lime
Burnt lime	
Lime shells	
Caustic lime	
Slaked lime	Lime and water
Chalk	Lime and carbonic acid
Limestone	
Marl	
Old mortar	
Basic slag	Lime and phosphoric acid with lime in excess
Basic superphosphate . .	Lime and phosphoric acid with lime in excess

2. *Neutral salts* in which lime is already neutralised by a strong acid:

Gypsum	Lime and sulphuric acid
Bones Mineral phosphates	Lime and phosphoric acid

3. *Acid salts* which contain more acid than the lime can neutralise:

Superphosphate Dissolved bones	Lime and phosphoric acid with phosphoric acid in excess

It will be seen readily that the last class is not at all suitable for plantation soils unless they have been treated previously with large quantities of lime. This may shed a light upon the failure of manures sent out from home for trial on some estates in this country.

Quicklime and slaked lime.

These are the most common forms of lime. Quicklime is obtained by burning either chalk or limestone in a lime-kiln. Quicklime readily absorbs and combines with water, forming slaked lime, while it also readily takes up carbonic acid gas from the atmosphere, forming carbonate of lime, which is similar in composition to pure chalk or limestone. For this reason quicklime should not be exposed to rain or allowed to stand long in heaps, but should be applied to the land as soon as possible.

In this country we have not progressed yet so far as to buy lime on a guarantee of its content, but under proper conditions quicklime should not be bought with more than 4 or 5 per cent. of magnesia in it.

Ground lime.

This consists of burnt lime (quicklime) which has been ground to a fine powder. It should be similar in quality to quicklime, but it is often impure, and contains less lime than ordinary quicklime. In this country ground lime would be much more expensive than quicklime, and much more wasteful.

Chalk.

This substance is really a soft limestone, and is a fairly pure form of carbonate of lime. When fairly pure it should contain about half its weight of lime. As far as our knowledge goes there are no visible supplies of chalk in this country.

Marls.

These are mixtures of earthy matter and carbonate of lime, but consideration of them is beyond the scope of this chapter.

Gypsum. This compound of sulphuric acid and lime is seldom employed alone as a manure, but it forms about two-fifths of the weight of ordinary superphosphate. It has already been pointed out that it is a neutral substance in which the lime has entered into combination with an acid.

Gas-lime. This form of lime is a by-product in the manufacture of coal-gas, for which lime is used as a purifying agent. It consists of lime more or less saturated with compounds of sulphur. It is liable to considerable variation in composition, and very often has little basic property left in it, and so cannot take the place of lime or chalk. It contains small proportions of sulphur compounds which are virulent plant poisons, and hence it should not be used where other simpler forms of lime are available. For this reason also no mixture of manures containing gas-lime should be considered by planters, especially as the percentage of lime present is small.

Basic slag. This is a by-product in the manufacture of steel, and is very largely employed as a phosphatic manure. It usually contains about 45 per cent. of lime, and a good proportion of this is available as a base, capable of neutralizing acids in the soil, though probably not more than 2 to 5 per cent. is in the form of free or "caustic" lime. The fact that the lime present is available for counteracting acidity in the soil renders basic slag of considerable value on soils deficient in lime, and it is, therefore, probably, one of the manures which will be found most useful in the future treatment of plantation soils.

QUANTITIES FOR USE AND METHODS OF APPLICATION. Coming to the question of quantities for use there are several factors which will play an important part in the consideration thereof, such as :—

(*a*) The nature of the soil.
(*b*) The history of the soil since planting.
(*c*) The use of lime for a specific purpose rather than for general application.

(*a*) *The Nature of the Soil.*—Under this section also we should have to consider the general lie of the land, and whether trees have been planted closely or at fairly wide distances. It will be obvious that in a new clearing or on widely planted areas not arrived at full growth there would be a larger loss of lime by weathering than on closely planted or older fields. More lime, therefore, would have to be applied for relatively the same areas

on the former types of land than on the latter. Again, on hill slopes there would be a greater loss of lime by water-wash than on flat lands, and we should require, therefore, a larger original outlay on the former than on the latter to obtain the same effect.

On the other hand, we see that flat lands in this country are often characterised by peaty soils rich in organic matter and relatively strong in acidity: whereas upland soils have a higher natural lime content. It has already been shown that lime is to be used not only to neutralise the acidity of soils, but also to release and render available food materials now locked up in an insoluble form. For flat peaty lands, therefore, considerably more lime may be used with effect than on hill soils, apart from the consideration of a larger loss by wash on the latter type of lands. On all "sour" (acid) soils the same will hold good.

On dry lands, as pointed out before, lime often has a beneficial effect in opening out stiff soils, in conjunction with efficient digging, and helps to create a good friable surface soil. For clay lands, therefore, quite a large quantity of lime may be used in comparison with quantities used on average good soils.

(b) *The History of the Soil* since its virgin jungle days must also be known. There are estates, comparatively few in number, fortunately, where previous to the advent of rubber-growing all kinds of crops—pepper, tapioca, gambier, coffee, etc., were taken from the soil. It would not be fair to compare such soils with plantation lands which were planted with rubber upon virgin soil. Such lands from which varied crops have always been taken always show their poverty by the stunted growth of trees, and in such cases it is apparent that the soil should be well limed once or twice at intervals of six to nine months, and *only then should manuring follow*. This is a point which has been made plain in a previous paragraph: it should be borne in mind that ordinary manures containing superphosphate should not be used until soils deficient in lime have had that deficiency supplied.

(c) *Liming for a Specific Purpose.*—Quite apart from the general application of lime it is possible to apply lime locally for a specific purpose. This may be illustrated by citing a case which occurred on an estate in the Klang district. In flat peaty soil the young trees grew very well until about eighteen months old. At this age they suddenly began to look sickly, although there was no apparent disease. In such an acid soil it was possible that the sickly appearance might have been due to the fact that the roots had gone so deep as to strike a very acid

subsoil. This was thought to be the case, and local application of lime was advised at the rate of 4 lbs. per tree forked in a radius of 3 ft. from each tree, to be repeated if necessary in six months time. An improvement in the trees was plainly apparent after two months and at the present time, one year after the second application of lime, the trees compare well with any other trees of the same age in spite of having been thrown back in growth.

Quantities.

It will be understood readily from the foregoing arguments that so many little factors influence the consideration of the question of quantities that it is practically impossible to lay down a general standard applicable to all plantation soils. Nothing more can be given than a general line of guidance, and such quantities will need to vary according to the nature and history of the soil.

1. For *peaty acid soils* one would advise the application of lime at the rate of 7 lbs. to 8 lbs. per tree calculated over the acreage, according to the number of trees per acre, on widely planted areas. For closely planted areas the total quantity may be calculated on the basis of 6 lbs. per tree.
2. For *ordinary flat land* soils lime may be applied at the rate of 5 lbs. per tree on widely planted areas and 4 lbs. per tree on more closely planted fields.
3. For *hill land (sloping) areas* the calculation may be made at the rate of 7 lbs. per tree for widely planted fields and 6 lbs. per tree for closer planting.
4. For *soils which have been under other crops* previous to planting with rubber trees lime may be administered at the rate of 4 lbs. per tree repeated after an interval of six or nine months.
5. For *stiff clay lands* where it is necessary to make a top soil it would be advisable to dig over well and lime at rate of 6 lbs. per tree, repeating the operation within twelve months.

These figures are only intended for general guidance and the quantities may be increased or diminished to suit local conditions. It may be remarked that the quantities are smaller than those recommended by other writers, and that the proposed intervals are shorter. It is customary to advise three or four times as much lime as a rule, but only at intervals of three or four years. In the opinion of the writer most Malayan soils require frequent

cultivation after some years, and by applying fairly moderate quantities of lime at shorter and more frequent intervals probably the maximum benefit is derived. On the generality of estates it will be found only necessary to apply these quantities of lime at intervals of nine to fifteen months in preference to applying larger quantities at intervals of three or four years.

On peaty lands and clay soils repeated applications can be given at the shortest interval consonant with practicability if the full benefit is to be derived.

METHODS OF APPLICATION.

Lime may be applied to the land by the simple method of broad-casting, but it is plain that tropical downpours would lead to excessive loss of lime. Such a method, although cheap, is not to be recommended, therefore, and there can be no doubt that the only sound method of application is by forking or digging. Not only is the lime well placed and liable to less loss by water-wash, but the full benefit of turning over the soil is derived. In fact, these two processes of turning over the soil and liming go hand in hand. Benefit is derived, no doubt, from each individually, but the full benefit is not gained unless the two are combined. Particular attention should be directed to the supervision of this work. The soil should be really dug up to a depth of from six to nine inches wherever possible. Otherwise there results a certain waste of expenditure and the returns will be correspondingly deficient. On average soils where both forking and digging may be done it will rest with the management to decide which method is the better and cheaper. On some old peaty areas digging is quite impossible, as the lateral roots are so near to, or above, the surface. Where, as in close planting, they are also interlaced, it becomes even difficult to fork over the soil, and in such extreme cases probably the best method to employ would be to bore holes with a large pointed stick and fill these holes with lime.

In the general cases where forking or digging is possible the lime may first be broadcast and then worked in. In the case of very young areas it would not be wise to broadcast. All the lime should be applied locally, within a radius of 3 ft. from each tree. For older trees it will be obvious that the feeding rootlets lie beyond this distance, and in the majority of cases as the trees become older the root system of adjacent trees are very thoroughly interlaced. The only method of application in these cases must be therefore first by broadcasting.

GREEN MANURES.

It is very probable that if a consensus of opinion were obtained from planters in the Federated Malay States on the subject of green crops, whether intended for catch-crops or as cover plants, such opinion would be expressed against their use. The grievance against green crops is the outcome of experience with plants which were not at all suitable for the purpose, and the recollection of the labour and expense involved in getting rid of some of them is very distinct.

It would be wrong, however, to conclude from these experiments that beneficial results do not accrue from the employment of some forms of green manures. Experience in other countries goes to show that suitable green crops under correct conditions may be of invaluable aid to the agriculturist. What is really needed is exact knowledge of the most suitable plant. We know that such plants as the cow-pea, the velvet-bean and ground nut in various parts of the world have been of inestimable value in enriching soils deficient in nutriment. None of these have been tried seriously on estates in Malaya.

One of them is cultivated at the present time by Chinese gardeners in our country, and it has been grown by a few planters. It seems to the writer, however, that it has not been given a fair trial. Probably it was grown as a catch-crop on flat and wet ground more than as a cover-plant and soil-enricher on sloping and drier lands. The results, we are given to understand, were not encouraging. It could be pointed out here that there is a perpetual inquiry for cover-plants suitable for preventing or diminishing "wash" from hilly slopes. Abandoning the idea of making the plant a catch-crop, and reverting to its value as an enricher of soil, and a possible agent for diminishing soil-wash one would be strongly inclined to favour another trial.

The plant referred to is the ordinary ground-nut, pea-nut, "monkey-nut," or pistache. There are several varieties, but the one most suitable would be the dwarf plant, which grows to a height of about six inches. The seeds may be planted in broad strips about six feet wide between rows of trees, and the preparation of these long beds would provide a fitting opportunity for applying lime first at the rate of about four piculs to the acre.

Experiments made at the Kuala Lumpur gardens of the F. M. S. Department of Agriculture went to show that the plants grew strongly and arrived at maturity in about three

months. They grew in a dense form suitable to prevent soil-wash. As a crop, however, the value in this experiment was not great, as many of the nuts suffered from attacks by worms. It was judged from results of the experiment that for cropping purposes the plant does not need a great amount of moisture; in fact, it was a just inference that the growth would have been better on sloping land which would not hold water to any great extent.

The great value of such a cover-crop lies in the fact that the growth of the plant increases the amount of nitrogen in the soil. This is effected by little nodules on the roots which, in combination with definite and characteristic micro-organisms, have the power of utilising and fixing the nitrogen of the air and transforming it into plant food. The nitrogen thus assimilated by the micro-organisms in the root nodules is in part appropriated by the crop; and when the plant begins to decay the organisms and nitrogen are distributed within the soil. Hence, when such a crop as ground-nuts is raised, the amount of nitrogen in the soil is increased instead of being dimininished as in the case of raising a grain crop.

An advantage such as this cannot be over-estimated. Moreover, in ordinary working there would be no pressing necessity to take the crop. When the plant had arrived at maturity (in about three months) the whole of the decaying vegetation, together with the nuts, could be dug well into the soil to its great enrichment.

It is thus shown that not only are there possibilities in such a plant in the saving of wash and retention of moisture in the soil, but that the condition of the soil would be much improved by the addition of nitrogenous compounds.

As a definite instance of the value of the ground-nut as cover-plant or ground crop, it may be noted that some years ago experiments with the plant in the Lower Soudan were such a success that what was once certainly unprofitable land has been made to produce excellent crops of cotton.

For these reasons, it would seem to the writer, experiments might well be tried on estates having sloping and well-drained land; and it is probable that the results would well repay the trouble and expense incurred.

VALUE OF CHEMICAL

It has been usual in the past to place great reliance upon the deductions made from results obtained by an analysis of soil.

From these results it was customary to lay down definite guidance for agriculturists, which guidance usually obtained implicit obedience. Thus if a soil was found to contain a smaller amount of potash salts than usual, a manure containing potash was prescribed and administered to the soil. There must have been instances in which it was noted that the actual results obtained from the manured soil were not in proportion to the benefit anticipated, and probably such instances were regarded as accidental. In the light of progressive research work in soil analyses, however, these discrepancies have a definite educational value, and have raised many pertinent points for research. Thus it has been found that two soils may be practically identical in chemical composition, as revealed by the ordinary methods of soil analysis, and yet they may differ greatly in fertility. Again, it is averred that by special methods there have been extracted from poor soils small amounts of complex substances which, if administered to good (fertile) soils even in extremely small quantities, will render the soils to a great degree sterile. These substances are not to be detected by the ordinary methods of soil analysis, and it is advanced that the difference in fertility between any two otherwise identical soils may be accounted for by the presence of traces of these bodies. However that may be, it is now acknowledged that it is not wise to place implicit reliance upon the ordinary deductions which are made from the results of soil analyses. Nevertheless, soil analyses have some value, provided that the results are considered in conjunction with an intimate and practical knowledge of the character of the lands from which the samples of soil were taken. It would be a matter of extreme difficulty to determine the relative values of soil analyses and such intimate knowledge gained by observation of the physical character of soils, but some leading chemists who have for years conducted soil analyses and have done much experimental work, have expressed an opinion that an observant practical agriculturist with an intimate acquaintance of the nature of the soils in a particular district could give advice as to the treatment which might possibly be of greater value than deductions drawn from the results of chemical soil analysis alone.

ANALYSIS OF THE SOIL.

On the other hand, it is certain that great value is to be ascribed to what is known as the mechanical analysis of soil. This is distinct from chemical analysis, and consists of a number

MECHANICAL ANALYSIS OF SOILS.

of operations in which the dry soil, after adequate preparation by breaking up into small particles, is passed through a number of sieves of varying mesh. The soil may thus be divided into portions composed of particles of different sizes, the proportions of which are calculated against the weight of the original sample taken. These portions are classified according to the size of the particles, and range from coarse gravel and sand down to fine silt powder. A great deal may be read into the results of the mechanical analysis so obtained, as upon the various proportions of the classified particles depend the ability to drain the soil, the extent to which water may percolate, the degree to which the soil will retain moisture, the ease or otherwise with which rootlets may penetrate through the soil, whether the soil will "pack" hard on the surface and so allow moisture to run away instead of percolating, and so on. It will be obvious, therefore, that the information to be derived from mechanical analysis of soil is positive and extremely valuable, whereas it has been shown that very often the value of chemical analysis of soils, if considered alone, is extremely doubtful.

These remarks on the value of soil analysis have been called forth by the fact that recently there has been a demand from estates in the Malay State for soil analyses with a view to the question of artificial manuring; and the writer considers it desirable to point out that managers who obtain results of such analyses should accept these results, or the deductions therefrom, with a certain amount of reserve. Certainly they should only be considered in conjunction with the intimate knowledge of the same soils as gained by the planter's own practical experience and personal observation.

Utilisation of rubber seeds.

Although this subject has been discussed in various scientific and planting publications, it may be worth more than a brief note in these pages, as inquiries are constantly being received at the laboratory.

It certainly does seem a pity that seed is now allowed to remain on the ground to the encouragement of rodents of all kinds. Several estates have received good offers from interested firms for the sale of seeds, but in the decorticated condition, *i.e.* minus the hulls or shells. It would be perhaps a little too wide to say that some of these offers have been allowed to fall to the ground because managers were doubtful of their ability to supply decorticated seed. There need have been no apprehension on

that point, as it has been shown that a simple machine on the lines of a coffee huller will crack the shells without damaging the kernels. Means of decortication.

That there is absolute need of decortication must be evident to the most elementary student of the subject. Probably few planters, if asked to gauge the proportionate weights of the kernel and shell of a rubber seed, would come within a considerable distance of the correct answer. From actual experiment in weighing some thousands of kernels and their outer cases separately, the proportionate weight of kernels to shells worked out at:— Need of decortication.

5 : 3

Consider further that a large percentage (about 20 per cent.) of the fresh kernel is composed of moisture, and it will be evident that by shipping decorticated and dried seeds there is a distinct saving of at least 50 per cent. in comparison with the freight on undecorticated seed; over and above the fact that there is much more possibility of the kernels arriving in good condition and free from mould when decorticated than if the seeds were shipped whole. Need for drying kernels.

It has been recommended elsewhere that the drying be effected by means of rotary kilns, beneath which the dried hulls or shells may be used as fuel. No doubt this would be, in the long run, the most economical method were we sure of a continued demand for the seed; but in the meantime the barbecue method of drying doubtless will be found effective. Means of drying kernels.

The kernels in drying lose about 20 per cent. of moisture, and it should be seen that they are thoroughly dried in the sun. They may then be packed in bags for shipment. It has been shown in actual experience that, provided the kernels have been properly dried, they arrive Home in good condition when packed in bags. Packing.

Quotations have not reached the writer very recently, but some short time ago they ranged from offers of £9 per ton (decorticated seed) to £12 per ton, *c.i.f.* any English port, packed in bags. Price obtainable.

Against this figure we have to obtain information on the following points:—

(1) Cost of collection of seeds.

(2) Cost of decortication and drying.

(3) Cost of transport and packing.

Concerning the first point there has been a certain amount of

discussion, and the experience of managers varies considerably, but as far as our information goes at present, by employing children as pickers, the seed may be collected at the rate of 5 cents per 1000 easily.

On the second and third points our information is rather uncertain, and in all probability managers will be better able to judge according to local conditions. It seems certain, however, that these costs should not exceed one-half the cost of collecting.

With these facts in mind we are now in a position to arrive at some idea of the margin to be allowed for reasonable expenditure and profit.

Number of seeds to the ton.

In arriving at the number of seeds necessary for one ton of kernels, some authorities have calculated on the basis of 160 seeds (dry) to the 1 lb., which we suggest is too low a figure. From actual weighings made at the Department of Agriculture of some thousands of seeds at a time it was found that the average weight of batches of 2000 fresh seeds was 10 lb. 11 ozs., which works out at approximately 180 seeds (fresh) to the 1 lb.

As the proportionate weight of kernels to hulls is 5 : 3, it follows that the number of *fresh* kernels to the 1 lb. would be:—

$$\frac{180}{5} \times 8 = 288 \textit{ fresh kernels to the } 1 \textit{ lb.}$$

Further, there is a loss of 20 per cent. by weight of moisture when the kernels are dried out, so that the actual number of dry kernels to the 1 lb. works out at:—

$$\frac{288}{1} \times \frac{100}{80} = 360 \textit{ dry kernels to the } 1 \textit{ lb.}$$

By simple multiplication, this is equal to:—

806,400 *dry kernels to the ton*,

or, for purposes of rough calculation, 800,000 to the ton.

Previous figures given elsewhere were too low, and it is calculated that those figures were at least 20 per cent. in error.

On the basis given above, of 800,000 seeds eventually yielding 800,000 dry kernels, the cost of collecting per ton of dry kernels obtained would be (at 5 cents per thousand) in the order of $40 (forty dollars) or roughly £4 14*s*.

Assuming that the price offered were at the rate of £10 per ton of dried kernels, packed in bags, and shipped *c.i.f.* any port in England, there remains a margin of £5 6*s*. out of which the costs of hulling and drying, of packing, of transport, freight and

incidental expenditure have to be deducted before any profit can be calculated.

The cheapest rate at which seeds have been collected in this country, we believe, is approximately 1*d.* per 1000, and this not on a very extensive scale. The cost of collecting 800,000 seeds at this rate would be £3 16*s.* 8*d.*, which, deducted from £10 per ton, would leave a balance of £6 3*s.* 4*d.* for the further processes and freight, without calculating profit.

If we assume that the other processes will cost roughly 25 per cent. of the cost of collection (at the rate of 1*d.* per 1000), there would remain a margin of £5 16*s.* 8*d.* per ton out of which local transport, shipping freight and profit has to be found.

Knowing the freight, etc., managers will be able to see what profit remains. It must not be forgotten that in these calculations only ton lots are considered, as smaller lots would be of no use to the consumers.

It has been pointed out, however, and very justly too, that there is another important factor entering into these calculations, *i.e.* the question of making allowance for a certain proportion of bad seeds which must inevitably be found in each harvester's collection. This proportion of bad seeds will vary even during the height of the seed harvest; but on the whole it would seem safe to base one's calculations not upon a rate of payment for collection at 1*d.* per 1000, but at the rate of 5 cents per 1000.

Looking at the whole question broadly there would appear to be a probable margin of profit ranging from £2 to £2 15*s.* per ton of dried kernels, a margin sufficiently wide to offer inducements to the manager economically disposed. Perhaps the planting industry is at present too favourably circumstanced to give such profits due consideration, but there may come a time when a margin of £2 per ton on dried kernels of rubber seeds will be thought worth obtaining.

For the economical manager it might also be worth remembering that even the dried seed-pods have a use. Those possessing smoke-houses may be glad to know that, failing other fuel, the dried seed-pods so abundant in the fields make good material for burning. The smoke caused is not too rich; and if the seed-pods are mixed with timber a very suitable smoke results from the combustion of the mixture.

The whole seeds have been employed on one or two estates for creating smoke, but they are not to be recommended strongly on account of the peculiar smell which the smoke imparts to the

rubber. On several occasions the writer has been able to detect easily this peculiar smell on samples of rubber submitted to him, and could almost locate these particular estates simply by smelling various samples. Sometimes also a peculiar greasy surface on smoked sheets results from the use of whole seeds as burning material. This oily or greasy surface deposit has been responsible for reports of rubber being over-smoked.

INDEX

THE END

PRINTED BY
WILLIAM CLOWES AND SONS, LIMITED,
LONDON AND BECCLES.